

Effects of Space Exposure on Metals Flown on the Long Duration Exposure Facility

H. Gary Pippin and R. J. Bourassa

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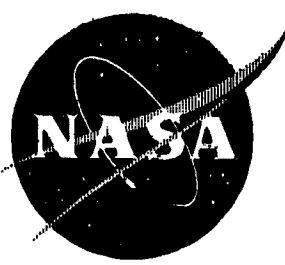
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EFFECTS OF SPACE EXPOSURE ON METALS FLOWN ON THE LONG DURATION EXPOSURE FACILITY

FOREWORD

This report describes the results from the testing and analysis of metals flown on the Long Duration Exposure Facility (LDEF). This work was carried out by Boeing under two Contracts, NAS1-1822 Task 12 (October 1989 through May 1991), and NAS1-19247, Tasks 1 and 8 (initiated ; 1991). Sponsorship for these two programs was provided by the National Aeronautics & Space Administration, Langley Research Center, Hampton, Virginia.

Mr. Lou Teichman, NASA LaRC, was the NASA Task Technical Monitor. Mr. Teichman was replaced by Ms. Joan Funk, NASA LaRC, following his retirement. Mr. Bland Stein, NASA LaRC, was the Materials Special Investigation Group Chairman, and was replaced by Ms. Joan Funk and Dr. Ann Whitaker, NASA MSFC, following Mr. Stein's retirement. The Materials & Processes Technology organization of the Boeing Defense & Space Group was responsible for providing the support to both contracts.

The following Boeing personnel provided critical support throughout the program.

Sylvester Hill	Task Manager
Dr. Gary Pippin	Technical Leader
Dr. Steven W. Spear	Analysis
Dr. John L. Golden	Analysis
Valerie A. Loebbs	Testing and Analysis
Jesse T. Cherian	Testing and Analysis
Mark Dubois	Testing and Analysis

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1.0 INTRODUCTION

The Long Duration Exposure Facility (LDEF) greatly extended the range of data available for metals exposed to the low Earth orbit (LEO) environment. The effects of LEO exposure on metals includes meteoroid and debris impacts, cosmic rays, solar particles, solar radiation, thermal cycling, oxidation and contamination. The LDEF environment primarily affected metals surface properties. Surface property changes afford a means to study the environment as well as in-space stability of metals.

The objective of this report is to summarize the effects of the LEO environment on the various metals carried on LDEF experiments and on metals making up the external surfaces of LDEF. The effects to be considered are changes in surface texture, oxidation depth, erosion depth, material growth, contamination, concentration of surface elements, physical properties, thermal properties, and optical performance. Data on these effects will be summarized for each metal.

Much of the information used herein is published in NASA Conference Publications (refs. 1-3). Overviews of LDEF materials findings are presented in references 4, 5, and 6. Additional material used herein has not yet been published by NASA. These additional findings include some papers presented at the Third LDEF Post-Retrieval Symposium, November, 1993 and work conducted subsequent to this meeting.

2.0 DESCRIPTION OF LDEF

The LDEF was designed to utilize the two-way transportation capability of the Space Shuttle and was deployed in a nearly circular low Earth orbit (LEO) on April 7, 1984. The initial mean altitude for the mission was 482 km and the orbit was inclined 28.4° to the equator. Mission duration was 2,106 days or nearly six years. Figure 1 shows LDEF as photographed from the Shuttle crew cabin window during recovery. The following description of LDEF is based on that given in NASA SP-473 (ref.7).



Figure 1. A view of LDEF from the crew compartment of the Space Shuttle Columbia during retrieval operations (NASA photograph).

2.1 Structure

The geometry and coordinate system of LDEF are shown in Figure 2. The vehicle structure is 12-sided, 30-feet long, 14-feet in diameter, and weighs 8000 lb. The structure is an open grid of aluminum rings and longerons (fore and aft framing members). The center ring frame and end frames are of welded and bolted construction. The longerons are bolted to the frames. Intercostals (crosspieces positioned between the main rings) are bolted to the longerons to form intermediate rings. The main load of the LDEF is transmitted to the orbiter through two side trunnions on the center ring. A keel fitting on the center ring gives lateral support. An end support beam, attached by a pin joint to one end frame, takes vertical loads and ensures that loads through the attachment fittings are static.

In orbit, the long axis of the vehicle pointed away from the Earth. The coordinate system as indicated in Figure 2 is right handed. The z-axis and vehicle heading are nearly coincident. The y-axis is nearly horizontal. The x-axis points vertical, parallel to the long axis of the vehicle.

2.2 Designations of LDEF Rows and Bays

Bay locations for experiments are designated by row numbers and tray letters as shown in Figure 2. Looking toward the Earth end of the vehicle, row numbers increase in a clockwise direction (1 through 12). The tray letters increase upward in the vertical direction (A through F).

3.0 LDEF ORBITAL ENVIRONMENT

3.1 Angle From Ram

Because of LDEF's 12-sided geometry, atomic-oxygen fluence varied for experiments from row to row. Angle from the ram direction for each experiment bay is shown in Figure 3. The angle of each experiment tray surface with the ram direction was determined by the fixed structural geometry of the vehicle and its constant flight attitude while in orbit. The angle from ram varied for each experiment row. Thus, the LDEF was ideally suited to experimental determination of the effects of atomic oxygen on materials.

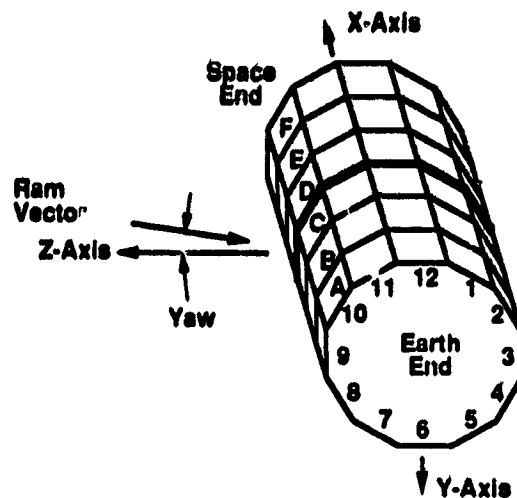


Figure 2. Designation of LDEF Experiment Trays

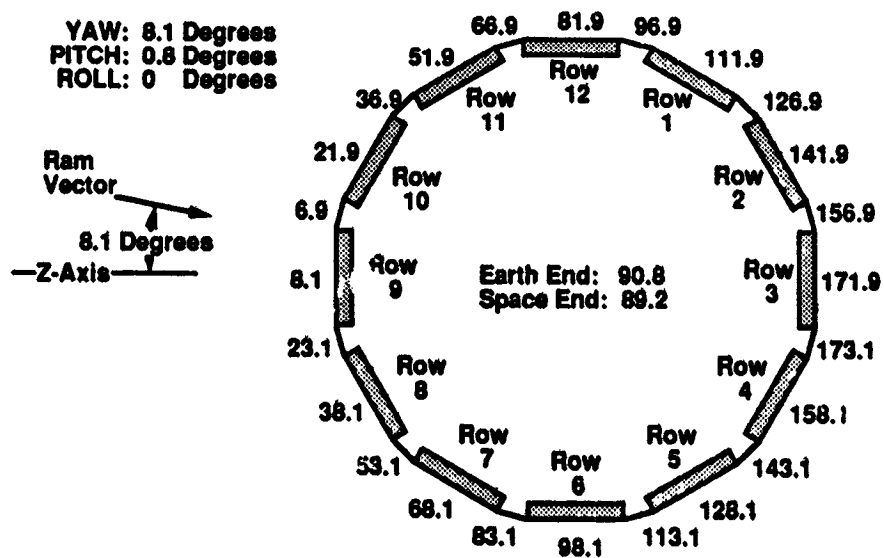


Figure 3. LDEF Angles of Surfaces From The Ram Direction in Degrees.

The angles given in Figure 3 include the pitch and yaw angles for the vehicle determined by Bruce Banks, NASA Lewis Research Center (ref. 8). The yaw angle is 8.1° with the spacecraft turned so that the ram direction lies between rows 9 and 10. Pitch angle is 0.8° with the space end of the vehicle pitched forward. Roll angle is zero.

3.2 Atomic Oxygen Fluence Versus Incidence Angle

Atomic oxygen fluxes and fluences for LDEF were calculated as described and updated in references 9 and 10. A brief summary of the factors affecting the atomic oxygen exposure of LDEF experiments is presented herein.

Molecules in a gas in thermal equilibrium have a Maxwellian speed distribution characteristic of their temperature. At 1000 K, the average molecular speed of atomic oxygen is 1.15 km/sec compared to an average speed of a spacecraft relative to the atmosphere of 7.24 km/sec at 400 km altitude in an easterly orbit. Thermal molecular motion affects atomic-oxygen flux on a surface at high incidence angles.

The atomic oxygen calculation takes into account the effect of thermal molecular motion. The effect is shown in Figure 4. The plot compares atomic oxygen flux corrected for thermal molecular velocity with values calculated by ignoring thermal molecular velocity. When thermal molecular velocity is considered, the calculations show that surfaces parallel to the ram direction receive approximately four percent of the head-on flux. Surfaces at angles greater than 90° from ram experience a small atomic oxygen flux. For incident angles less than approximately 87.5° , predicted atomic oxygen fluxes with or without the inclusion of thermal velocity are nearly equal.

3.3 Atomic Oxygen Fluence Versus Time

Atomic oxygen flux was not constant during the mission. Decreasing solar activity caused atomic oxygen flux to decrease during the first three years of flight. Thereafter, the combination of increasing solar activity and decreasing altitude caused atomic oxygen flux to increase rapidly. Figure 5 shows ram direction atomic oxygen fluence for LDEF expressed as a percent of total fluence for the mission. This plot reflects the combined effect on atomic oxygen fluence caused by varying solar activity and loss of altitude. Roughly 50 percent of the atomic oxygen exposure accumulated during the last six months of the LDEF mission. The last year of the flight accounted for roughly 75 percent of the exposure.

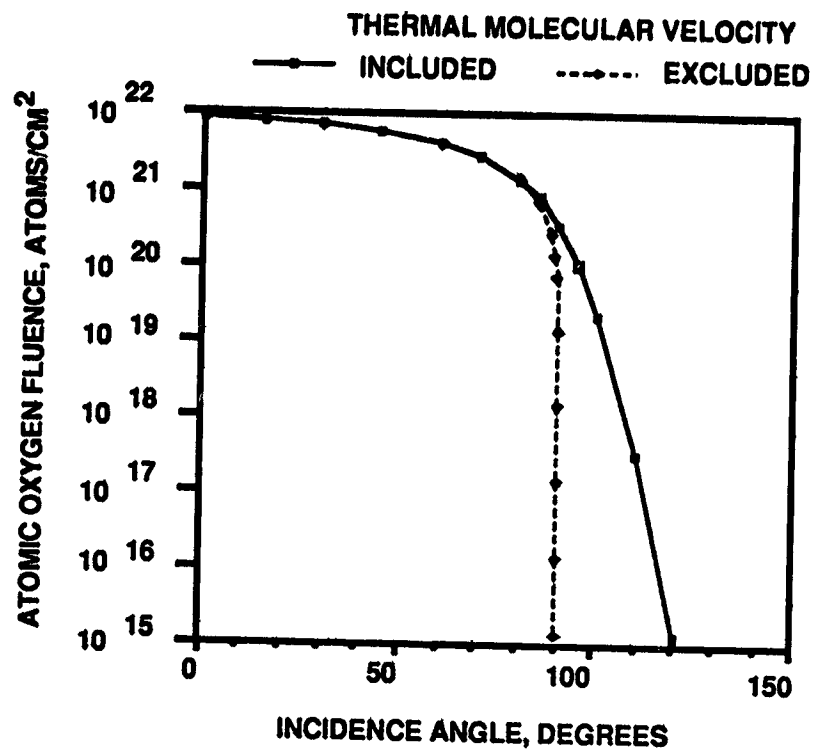


Figure 4. Fluence as a Function of Incidence Angle.

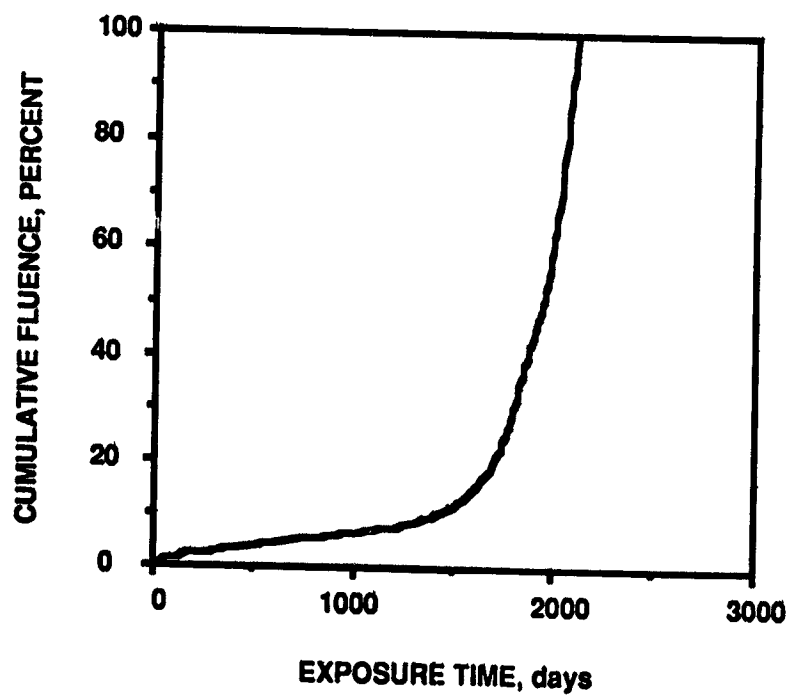


Figure 5. Fluence as a Percent of Total Exposure.

3.4 Atomic Oxygen Fluence

Figure 6 shows the mission total atomic oxygen exposure accumulated on each row and longeron during the LDEF mission. The view is of the Earth end of the spacecraft. In this view, row numbers increase in the clockwise direction. The ram direction lies between rows 9 and 10. All trays on a row received the same atomic oxygen fluence.

The data given in Figure 6 include an estimate of atomic oxygen exposure received by LDEF during an attitude excursion on retrieval which was added to the fluence accumulated during orbital flight. The attitude excursion provided most (row 1), or virtually all, the atomic oxygen fluence on row 1 (2.9×10^{17} atoms/cm²), longeron between rows 1 and 2 (1.5×10^{17} atoms/cm²), row 2 (1.5×10^{17} atoms/cm²), longeron between rows 2 and 3 (1.4×10^{17} atoms/cm²), and row 3 (1.3×10^{17} atoms/cm²). The values shown in parentheses are total exposure, mission plus retrieval. With the exception of row 1, which received a fluence of 1.2×10^{17} atoms/cm² prior to retrieval, insignificant amounts of atomic oxygen impinged on rows 1-3 during the on-orbit exposure.

Because the vehicle was pitched so that the space end was forward of vertical, trays on the space end of the vehicle received more atomic oxygen than did trays on the Earth end of the vehicle during flight.

3.5 Solar Exposure

Figure 7 summarizes cumulative equivalent sun hours (ESH) exposure from direct solar and Earth reflected radiation at each LDEF tray location (ref. 11). As may be seen from the figure, the highest solar exposure is to the space end and the lowest is to the Earth end of the vehicle. Of the 12 rows, the leading row and trailing row (rows 9 and 3 respectively) received the highest exposure. Those rows nearly parallel to the ram direction (rows 6 and 12 respectively) received the lowest exposure, about 60 percent of the leading edge exposure.

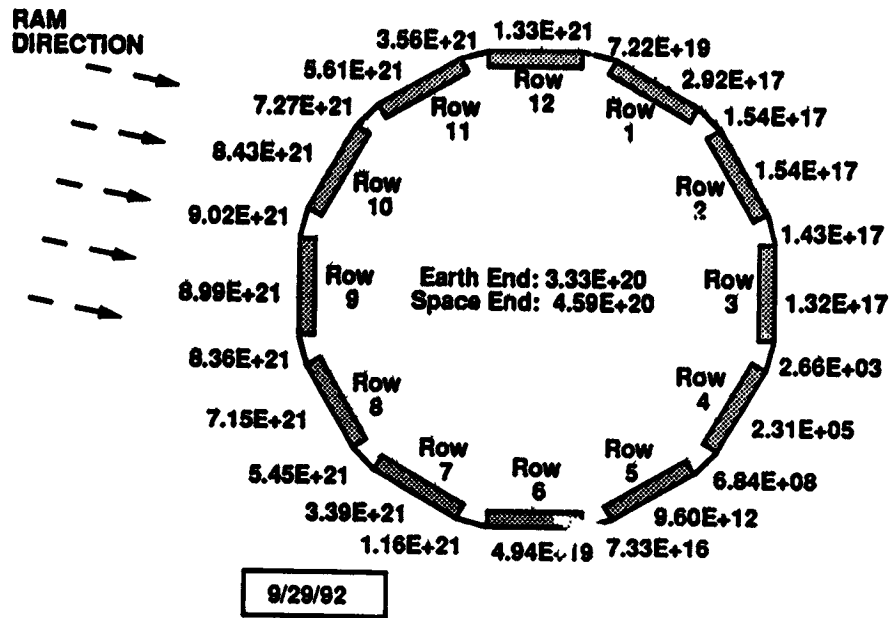


Figure 6. Atomic Oxygen Fluences (atoms/cm²) at End of Mission , Including Exposure During Retrieval.

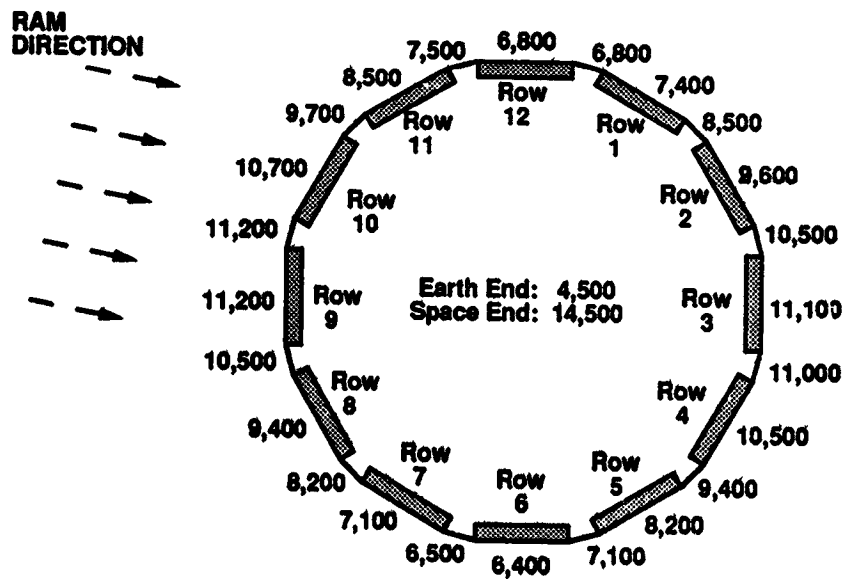


Figure 7. Cumulative Equivalent Sun Hours Exposure at End of Mission.

Build-up of cumulative equivalent sun hours with time is quite linear for Earth and space end bays and for leading edge and trailing edge rows, 9 and 3 respectively. Build-up of cumulative equivalent sun hours for north and south facing rows, 6 and 12 respectively, show a seasonal effect. Row 12 is oriented in a northerly direction and, hence, received the most intense radiation in the northern hemisphere summer and the least intense radiation in the northern hemisphere winter. The opposite is true for row 6, which is oriented in a southerly direction. Seasonal effects decrease as row orientation becomes perpendicular to ram direction. Seasonal effects are explained more thoroughly in reference 11.

4.0 LOCATIONS OF LDEF EXPERIMENTS

Fifty-seven science and technology experiments involving investigators from the United States and nine other countries were flown on the LDEF mission. Each of these experiments is discussed in reference 7. The arrangement of peripheral experiments on the LDEF structure for the LDEF mission is illustrated in Figure 8. The arrangement of Earth-end-tray and space-end-tray experiments for the LDEF mission is illustrated in Figure 9.

Typical trays for mounting experiment hardware to the periphery of the LDEF structure are 34-inches wide and 50-inches long. Trays for mounting hardware on the end frames are smaller, 34-inches square. The depth of the trays is varied as required by the experiments. For the LDEF mission tray depths were 3, 6, and 12 inches.

The weight that can be accommodated in the trays is 800 lb for peripheral trays and 200 lb for end trays. The combined weights of the mission experiments was approximately 21,400 lb.

CENTER RING

EARTH END

SPACE END

BAY ROW	A	B	C		D	E	F
1	A0175	S0001	GRAPPLE		A0178	S0001	S0001
2	A0178	S0001	A0015 A0187 M0006		A0189 S0001 A0172	A0178	P0004 P0006
3	A0187	A0138	A0023 A0034 A0114 A0201		M0003 M0002	A0187 S1002	S0001
4	A0178	A0054	S0001		M0003	S0001	A0178
5	S0001	A0178	A0178	P0005	A0178	A0044 S0050 A0135	S0001
6	S0001	S0001	A0178	P0003	A0201 S0001	A0023 S1006 S1003 M0002	A0038
7	A0175	A0178	S0001		A0178	S0001	S0001
8	A0171	A0056 S0001 A0147	A0178		M0003	A0187	M0004
9	S0069	S0010 A0134	A0023 A0034 A0114 A0201		M0003 M0002	S0014	A0076
10	A0178	S0005	GRAPPLE		A0054	A0178	S0001
11	A0187	S0001	A0178		A0178	S0001	S0001
12	S0001	A0201	S0109		A0023 A0019 A0180	A0038	S0001

Figure 8. LDEF Experiment Locations For Rows 1 through 12.

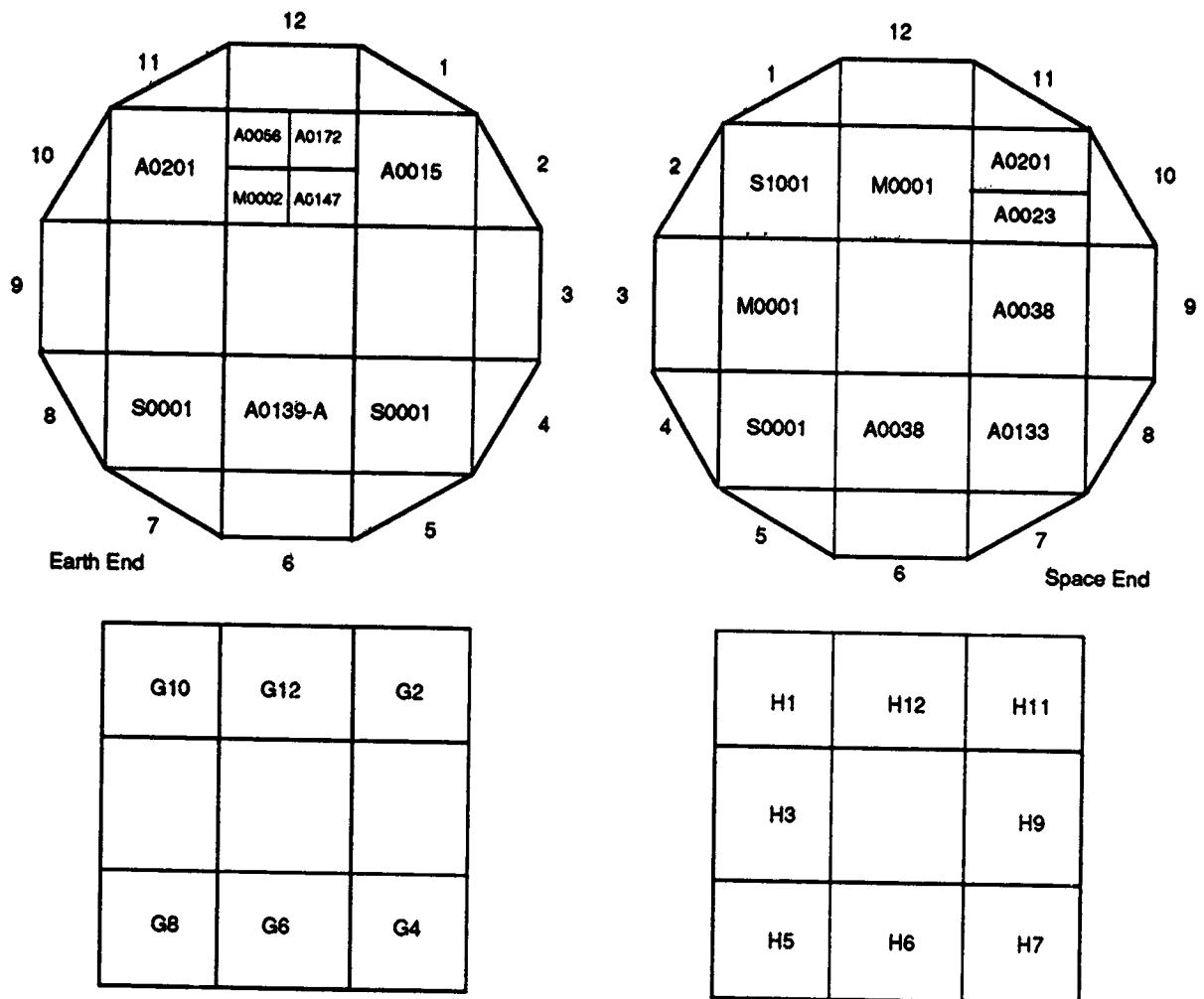


Figure 9. Designations of LDEF Earth End and Space End Experiment Trays and Locations of Experiments.

5.0 EFFECTS OF LEO ENVIRONMENTS ON METALS

A wide variety of metallic (and semiconductor) materials were flown on the LDEF. The mixture included pure metals, alloys, metallic coatings on selected substrates, and metal matrix composites (discussed in ref 12.). Aluminum, gold, titanium, copper, steel, and lead were used in specific engineering applications ranging from the structural members to impact collection plates, nuts and bolts, ballast, and thermal panels.

Metal alloys flown on LDEF include Monel, brass, bronze, Inconel, copper-beryllium, copper-nickel, tin-lead, and stainless steel. With the exception of the Monel wires on experiment A0038, and the stainless steel bolts, these materials were experiment support hardware, and not generally subject to direct exposure. Except for stainless steel, investigations carried out on these materials have been limited in scope. No anomalies of any kind have been identified as being due to these materials.

This report includes a comprehensive set of references which discuss performance of specific metals, results of analyses of bare aluminum clamps, copper grounding straps, and stainless steel bolts, and a comparison of results and summary of findings for each given material by different investigators.

The depth and nature of analyses on different specimens vary widely depending on the goal of the experiment. To organize and draw conclusions from many different sources results are covered metal by metal. A number of the findings summarized from A0114 are taken from unpublished studies. The principal investigator for this experiment is Dr. John Gregory of the University of Alabama-Huntsville.

Raw data for a series of studies on LDEF stainless steel bolts, aluminum clamps, and copper surfaces are included in the appendices of this report. Collectively, the appendices document the distribution of silicon based contamination on LDEF surfaces. Data for the initial surface characterization of the bolts are reported in appendix A. Appendices B and C are compilations of auger data from the aluminum tray clamp and stainless steel bolt head surfaces, respectively. ESCA data from surface analysis of copper grounding straps is reported in appendix D. ESCA survey spectra from selected aluminum tray clamp surfaces are reported in appendix E.

5.1 Aluminum

Most aluminum used on LDEF was chromic acid anodized to achieve desired thermal performance. The performance of the anodized material has been previously extensively reported (refs. 13-16). As part of M0003, Boeing flew an alodined plate and a sulfuric acid anodized plate on tray D3. On A0019, a bare aluminum (2219) frame was used to hold composite specimens. Areas of this frame were visibly contaminated, but this hardware was not examined quantitatively. Four tray clamps on both tray C9 and C3 were made of unanodized aluminum. Surface analysis data of these clamps using ESCA and depth profile analysis by Auger are presented in appendix A. Surface elemental composition for selected tray clamps as determined by ESCA measurements is also reported in this appendix.

Rockwell alodined the aluminum framework which held their composite specimens in place on experiment A0175. This material appeared faded and discolored in comparison with pre-flight photos, but no quantitative comparison is available.

While little change was observed in the optical properties of any aluminum material, the unanodized clamps have much poorer values of absorptance (α) and emittance (ϵ) in comparison with the anodized clamps. A polished aluminum specimen on tray D3 was in excellent condition post-flight with no change in optical properties.

Table 1 shows the results of post-flight optical properties measurements for selected bare and anodized aluminum clamps and a typical T-6061 aluminum panel for comparison. Measurements on the flight samples include results from both exposed and unexposed surfaces. Bare aluminum specimens were flown on tray D3, one on the Boeing module (ref. 17) and as one part of the M0002-1 experiment (refs. 18-19). This experiment also included specimens of Cu, Ni, Ta, Zr, Si, and W, each held in place by an aluminum bar. Locations of the experiment included trays D9, D3, and G12. The 82° orientation from ram for the Cu and Si specimens, coupled with the nearby structure and the position of these materials in a recessed portion of the tray minimized the atomic oxygen exposure. Figure 10 shows a post-flight photograph of the M0002-1 experiment mounted in its tray. The metallic specimens are flat plates mounted on the side of the impact "camera" assembly from the cylinder (specimens toward the top of the photo).

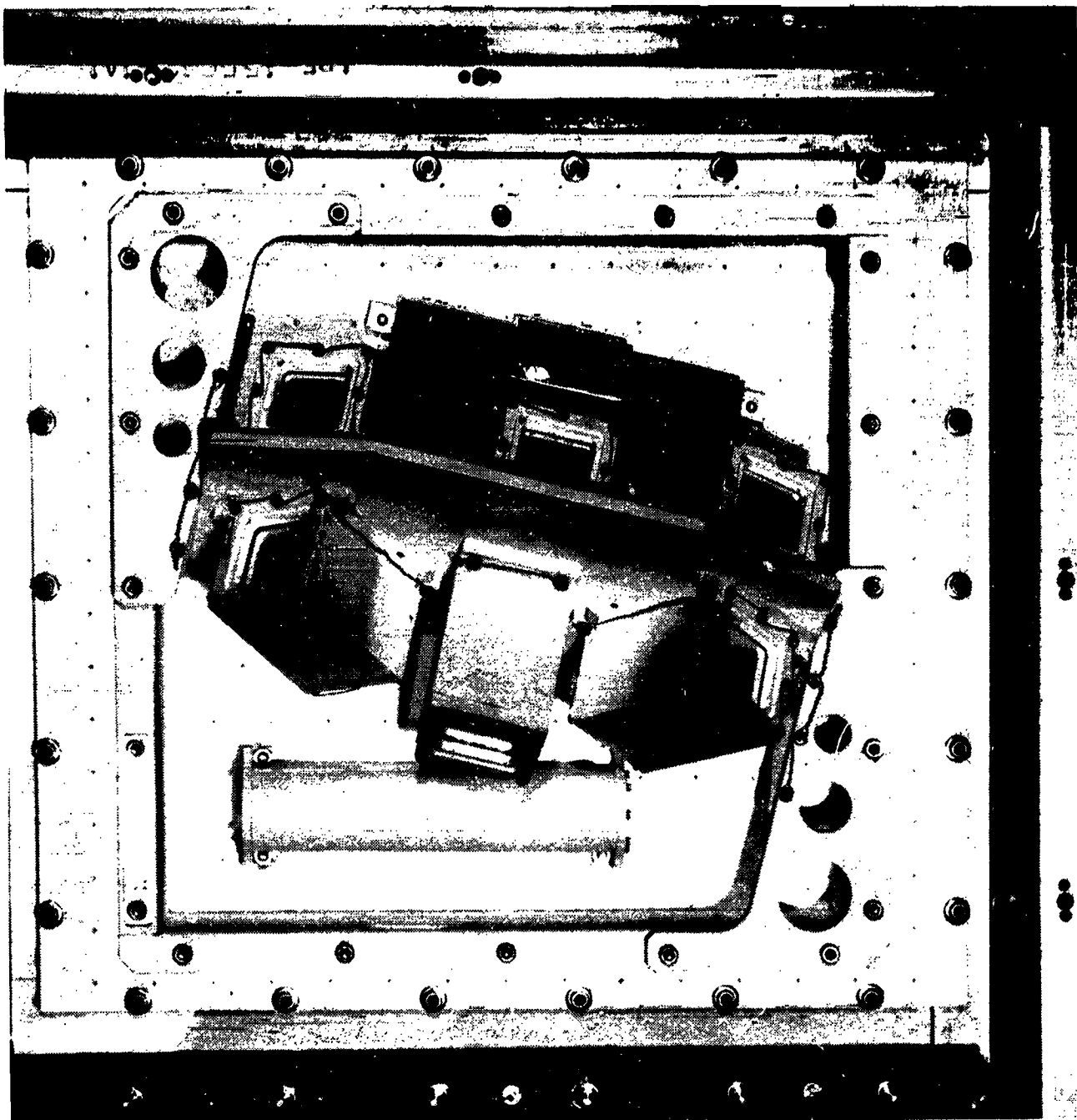


Figure 10. Photograph of a Module from the M0002 Experiment.

Specimen		α	ϵ
C3-5	exposed area 1	0.73	0.08
exposed area 2	0.74	0.08	
unexposed side	0.71	0.13	
C9-7	exposed area 1	0.70	0.06
exposed area 2	0.69	0.06	
unexposed side	0.72	0.09	
C9-2	exposed	0.31	0.17
unexposed side	0.31	0.19	
C3-6	exposed	0.33	0.15
unexposed side	0.31	0.15	
CAA control #4	side with paint button	0.31	0.20
"back"	0.31	0.18	
CAA clamp, row 9	exposed	0.34	0.145
unexposed side	0.34	0.145	
"Bare" 6061 panel		0.31	0.04

Table 1. Optical properties of bare aluminum clamps flown on the leading and trailing edges of LDEF compared with values for chromic acid anodized (CAA) and ground control materials.

P5.2 Cadmium

Cadmium plated roller bearings were flown on the Boeing module of tray D3. Post-flight examination of the cadmium showed some apparent wear, but this may have been due to pre-flight handling. Cadmium did remain on each of the 3 bearings. Cadmium plated washers, with an anodize overcoat, were used on the fastening system for the Boeing composite panel on tray D9. No evidence of wear or loss of cadmium was observed.



Figure 11. NASA post-flight photo of copper grounding strap from LDEF experiment A0178.

5.3 Copper

Bare copper specimens were flown on experiments A0114, M0002-1, and A0171. Copper was used as grounding straps at 17 locations where silverized Teflon thermal control blankets were used. Twelve of the straps were provided to Boeing for analysis. Optical properties were obtained for at least two locations on each clamp. A photograph of a copper strap is shown in figure 11. Plots of absorptance and emissivity versus atomic oxygen and solar exposure have been published (ref. 20) and are reproduced in figures 12 and 13. Data from measurements by other groups have been added to the measurements by Boeing. Each copper strap has two distinct regions, directly exposed to the environment, oriented at 15° relative to each other, which are large enough to allow optical measurements. Optical properties are shown in table 2. Detailed surface analysis has been carried out on selected clamps and a ground control specimen taken from the original roll of copper tape used to make the grounding straps. The ESCA spectra obtained for multiple locations along the selected clamps are presented in appendix D. Analysis of 5 grounding straps was carried out by ESA (ref. 21). Estimates were made of oxide thickness versus fluence. The oxide was identified as Cu_2O with a top layer of CuO which was likely formed post-flight during ground storage. Oxide coating thicknesses reported for samples from M0002-2 and A0114 (ref. 22) also show films in the 100 nm or thinner range, for exposed specimens. Optical properties have also been published for these specimens. The values reported for the A0114 specimen are for an optically thin specimen and were not corrected for transmission. A copper specimen was also flown as part of A0171 (ref. 23) and the optical values for this specimen are reported in table 3.

Specimen	angle from ram	α	ϵ
A10	36.9	0.532	0.060
A10	21.9	0.480	0.015
B7	53.1	0.513	0.050
B7	68.1	0.418	0.033
C8	23.1	0.595	0.021
C8	38.1	0.514	0.022
C11	66.9	0.392	0.016
C11	51.9	0.421	0.020
D11	66.9	0.442	0.028
D11	51.9	0.532	0.021
A2	156.9	0.387	0.019
A2	141.9	0.328	0.011
A4	143.1	0.366	0.020
A4	158.1	0.317	0.015
B5	113.1	0.363	0.013
B5	128.1	0.384	0.012
C5	113.1	0.352	0.015
C5	128.1	0.313	0.020
D5	113.1	0.323	0.017
D5	128.1	0.321	
F2	156.9	0.285	0.021
F2	141.9	0.301	0.012
F4	143.1	0.304	0.013
F4	158.1	0.327	0.014
Ground Control		0.232	0.017

Table 2. Optical properties from copper grounding straps and other selected copper specimens exposed on LDEF.

A0114	α_{un}	α_{ex}		
Row 3	0.29	0.29		
Row 9	0.37	0.86		
A0171	α_{pre}	α_{post}	ϵ_{pre}	ϵ_{post}
Row 9	0.354	0.556	0.965	0.961

Table 3 Optical properties for copper specimens from certain LDEF experiments.

COPPER GROUNDING STRAPS, ABSORPTANCE AND EMITTANCE ON LEADING SURFACES

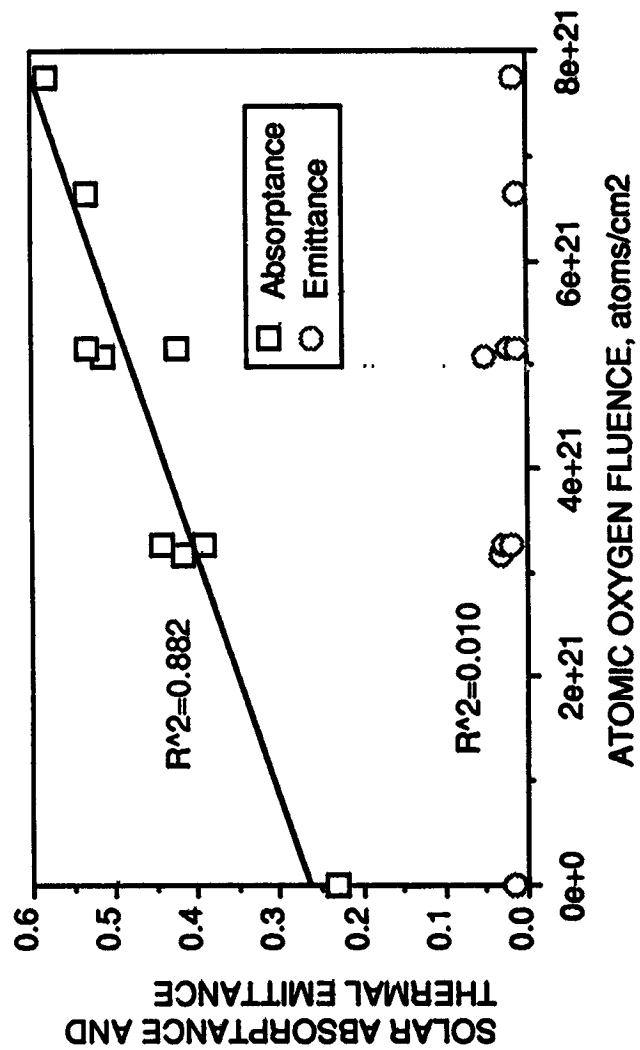


Figure 12. Absorptance and emittance of copper grounding straps on leading edge surfaces of LDEF as a function of atomic oxygen exposure.

COPPER GROUNDING STRAPS, ABSORPTANCE AND EMITTANCE ON TRAILING SURFACES

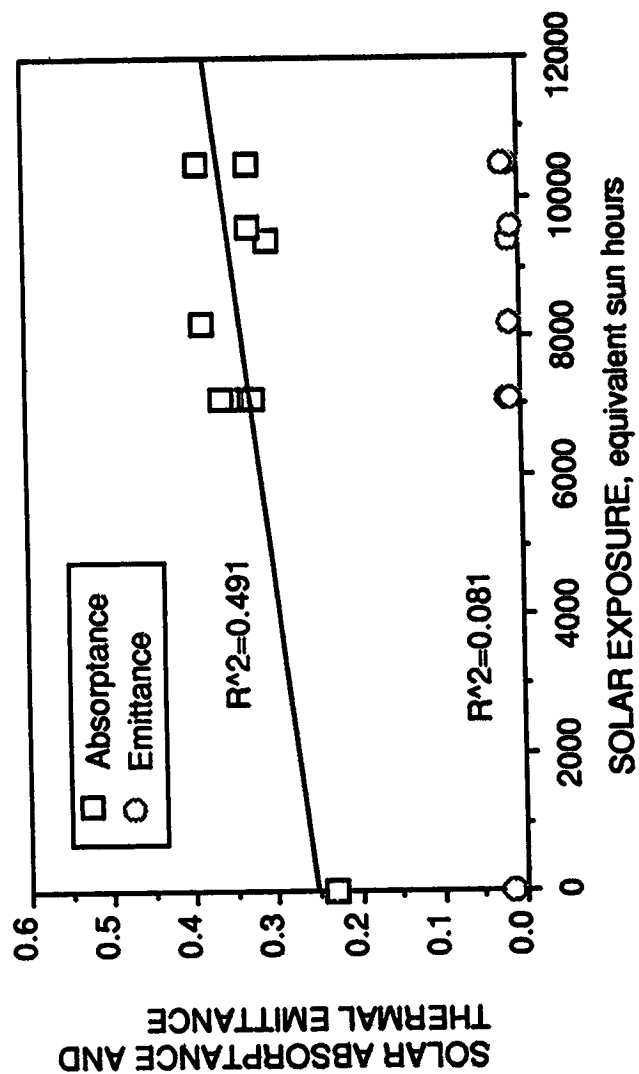


Figure 13. Absorptance and emittance of copper grounding straps on trailing edge locations of LDEF as a function of solar exposure.

5.4 Gold and Iridium

Gold plates were exposed on A0187, tray A3. This was the collection surface for a meteoroid and debris impact experiment. No surface analysis of this material has been carried out. No changes in the properties of the gold were noted for specimens flown on A0114 (ref. 22). A thin contamination layer was reported for these specimens and slight changes in reflectance are attributed to this film. Differences were also noted in appearance of leading versus trailing edge gold specimens, most likely attributable to surface contamination deposits and subsequent interactions with solar UV radiation.

5.5 Molybdenum

Molybdenum specimens on A0114 row 8 showed expected oxidation (ref. 22) and absorptance change (0.45 to 0.69). Slight changes in reflectance due to flight exposure were observed for trailing edge specimens. Formation of a thin contaminant layer is the likely cause. Similar changes in optical properties were observed for molybdenum A0171 specimens from row 8. An absorptance increase of 20 percent and an emissivity increase of about 2 percent was measured over the duration of the mission (ref. 23).

5.6 Nickel

Nickel specimens or coatings were flown on 4 experiments (refs. 18, 19, 22, 23, 24). Elemental nickel was flown on tray D3, M0003 experiment (ref. 25). In spite of the trailing edge location, the exposed portion of this specimen showed a 30 nm thickness increase relative to the unexposed area. This specimen was exposed to atomic oxygen for a brief period of time during retrieval. The oxide coating on this nickel specimen was highly porous, as were many of the thin metal oxides examined on exposed portions of metal specimens on the M0002 experiment. An extremely thin (1000 Å) nickel coating with a 600 Å overcoat of silicon dioxide protected composite substrate material on tray B9. The nickel specimen flown on A0114, row 9 showed an absorptance change of about 0.11. The A0114 nickel specimen on row 3 was essentially unchanged.

5.7 Silver and Osmium

Silver and osmium films, flown on the leading edge (experiment A0034), but exposed only indirectly to atomic oxygen, were both completely eroded (ref. 26). Identical trailing edge specimens show some oxidation. Exposed silver at leading edge locations showed darkening, surface roughening and oxidation. These effects were expected, given severe damage to silver observed on shuttle flights. A silver specimen from experiment A0171 showed absorptance changes from 0.251 to 0.872, and emissivity changes from 0.039 to 0.141, due to flight exposure (unpublished data, percent changes are shown in ref. 27).

5.8 Silicon

Silicon was detected on many LDEF surfaces and a number of localized sources have been identified. The silicon specimen from the M1002 experiment showed a distribution of oxide thicknesses across the specimen surface, most likely due to the oblique angle of incidence of the atomic oxygen and the complex shape of the surrounding structure.

Using ESCA techniques, silicon-containing species were detected on selected tray clamp bolt heads (A8-6B, B7-5A, E9-1C, F11-8B), from near leading edge locations. Infrared spectroscopy was used in an attempt to further identify the nature of the silicon-containing species. No residue was visible on the surfaces of the bolts selected for this examination. The bolts were washed in hexane because low molecular weight silicones should be soluble in this solvent. The heads of three bolts were individually rinsed with spectral grade n-hexane. The solvent was re-aspirated and pipetted onto a salt plate for IR analysis. The entire washer and bolt head of the fourth sample was rinsed with hexane. No spectral evidence of silicone was observed for any of the four bolts. This likely occurred because the silicone had polymerized and was no longer soluble in n-hexane, or was present at too low a concentration to detect using IR, or had been oxidized to SiO_x by atomic oxygen. Each of these reasons probably contributed to the null result from the IR measurements.

Survey ESCA spectra for these and other bolts are shown in appendix A. These bolts were selected to be representative of all the exposure environments present on LDEF. Detection of iron on many bolt surfaces by ESCA is an indication of a very thin film or incomplete covering of the surface. This is because ESCA probes only the first 20 to 50 Å of material and the iron source is the bolt alloy itself. To determine the nature of the silicon species (organic or inorganic) on the bolt heads, high resolution ESCA has been carried out on a selected set of bolts. Results of this effort are included as part of the stainless steel analysis.

5.9 Chromium

Stainless steel bolts used to hold the tray clamps contained Cr in the alloy. A portion of tray F6 and the Earth end panels covering about half the area on the Earth end of LDEF (photo) were black chrome plated. A detailed investigation was made into the appearance of the black chrome plated coated module cover on the McDonnell-Douglas experiment from tray F9 (ref. 28). Figure 14 is an in-flight photo of A0076, tray F9, showing the heat pipe electronics module cover in the lower left corner, with a piece of aluminum from the failed MLI blanket folded over one end of the module. Figure 15 is a post-flight close-up of the black chrome plated electronics module cover. Contamination has been ruled out as a cause of the discoloration pattern. While temperature extremes seem a likely cause, the end-of-life optical properties ratios (α/ϵ) are not great enough to suggest temperature driven phase changes. It is clear that the discoloration patterns are connected with the failure of the aluminum backed Kapton blanket and subsequent shielding of certain areas by the blanket remnants. Areas from black chrome plated Earth end panels were examined for oxide thickness and composition. These panels each have a lip oriented at right angles to the main area of the panel. The lip of panel 916-10A was mounted on the row 10 longeron with its surface oriented in the same direction as the row 10 trays. The curved region of the panel experienced a range of exposure from 22° from ram to 90° from ram.

5.10 Stainless Steel

Stainless steel bolts were used at virtually every set of exposure conditions on LDEF. The bolt heads of the bolts used to hold the tray clamps in place essentially viewed space, with most bolts having no line-of-sight view factor to other LDEF hardware. The only exception is that some bolts were line-of-sight to the trunnions and scuff plates. In the post-flight de-integration facility (SAEF II building clean room) at KSC, the bolts were sealed inside clean bags and placed inside clean plastic bottles. Therefore, the bolt heads make a valuable set of contamination witness plates, particularly when examined for potential silicone deposition.

One concern for the International Space Station is that shuttle proximity operations will cause certain space station surfaces to exceed their annual/mission budgets for silicon base contamination due to Space Shuttle outgassing. When the LDEF was in the payload bay of the Space Shuttle Challenger prior to deployment, and in the payload of the Space Shuttle Columbia after retrieval, the bolts were in direct line-of-sight to parts of a Space Shuttle. Analysis of LDEF bolt head surfaces offered a chance to determine if Space Shuttles may be a source of silicon contamination. While the results from the bolt head surfaces are suggestive, especially in combination with surface

analysis from other LDEF surfaces, no firm conclusion was reached from analysing survey ESCA spectra, Auger spectra, and elemental analysis values. Because silicon is a constituent of the alloy of which the bolts are made, the masking effects of organic contamination, coupled with the large variation in the organic content on the surfaces due to the wide range of atomic oxygen exposures, did not allow for a firm conclusion until high resolution ESCA measurements were carried out.

Table 4 includes elemental percent results determined by ESCA for each of the LDEF bolt head surfaces and control specimens examined. The data shows a strong correlation between atomic oxygen exposure and the percent elemental carbon on the surface. Because this data is reported on a percent basis, this variation affects the other reported values and may mask trends or show apparent trends which are not real. To put the reported silicon amounts on a common basis, the silicon percents were ratioed to the percent iron reported. The iron has only one source, the bolts themselves, and the amount should be constant from bolt to bolt. This analysis is complicated because the volume of material sampled in an ESCA measurement may include unknown proportions of contamination layer and bolt. Atomic oxygen not only removes organic material but oxidizes silicones to silicates, which also complicates this analysis. Auger analysis on selected bolts show a contamination layer about 45Å thicker on flight specimens relative to ground control specimens.

The Si peak energies in the ESCA spectra range from 102 to 104 eV, as expected for oxidized species; elemental silicon would show a peak at about 99eV. There is about a 1 eV difference in the silicon 2p peak of an ESCA spectrum between an organic silicone and an inorganic silicate, at 102.5 and 103.5 eV, respectively.

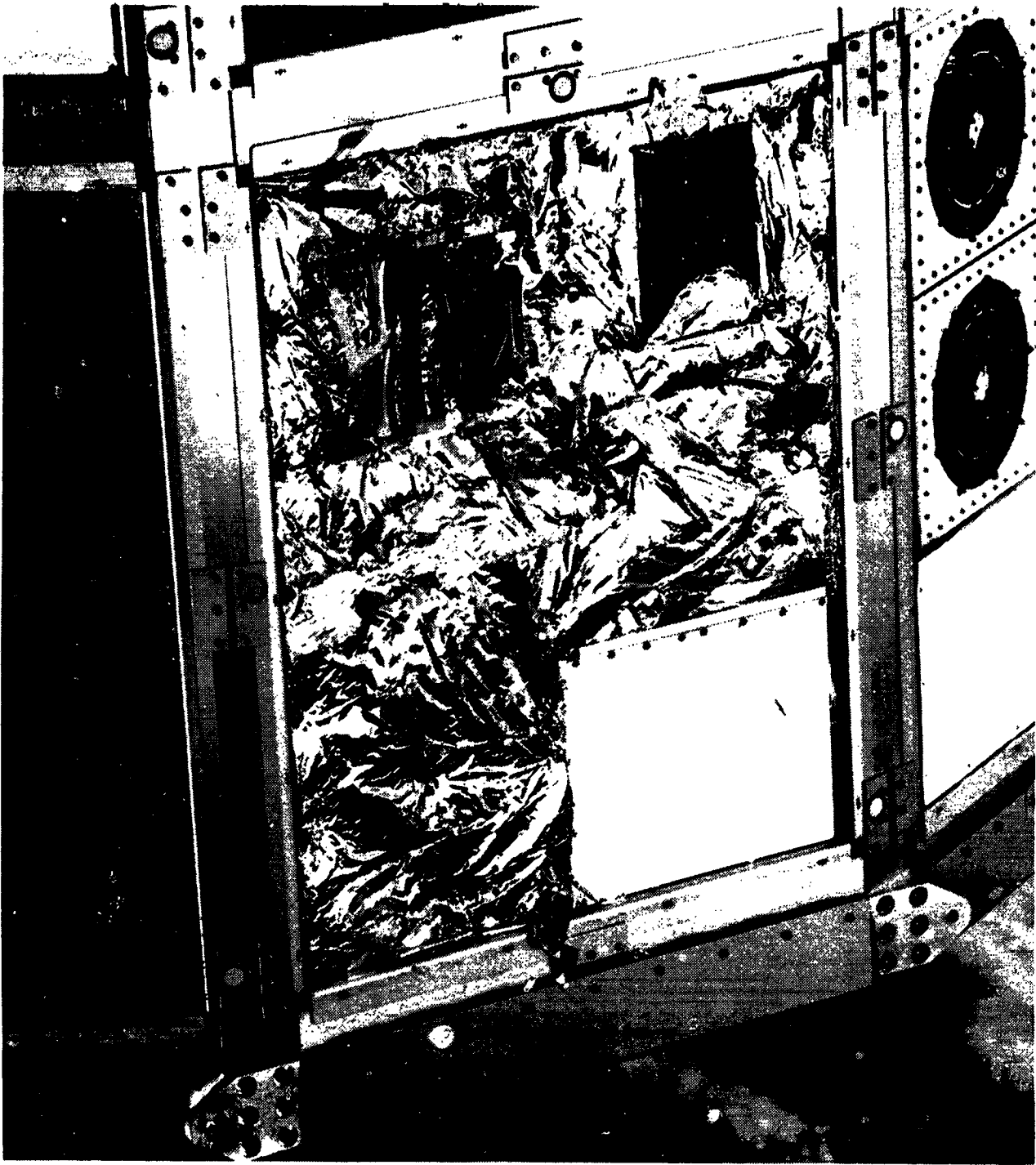


Figure 14. On-orbit photograph of McDonnell-Douglas experiment on tray F9.

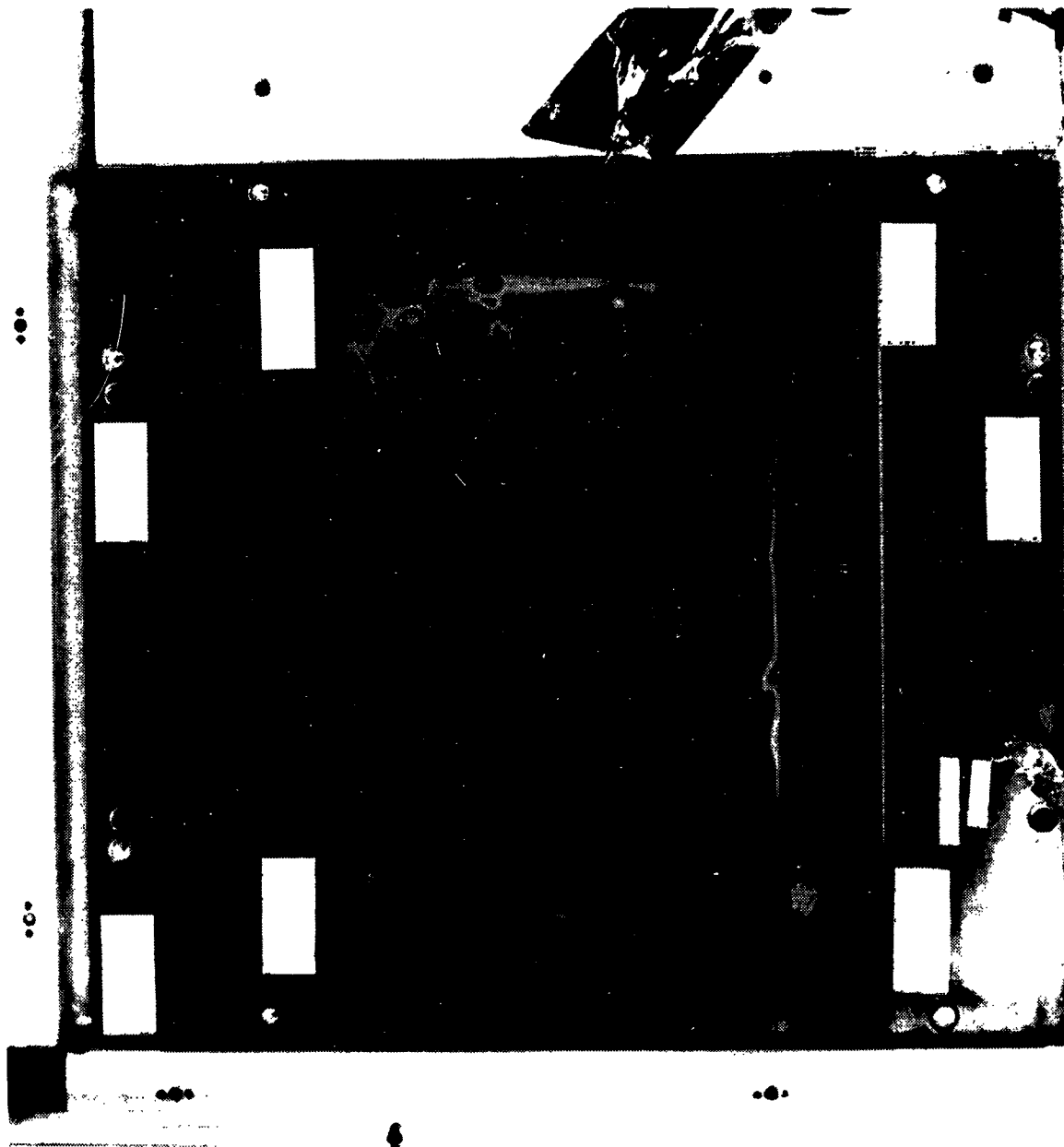


Figure 15. Post-flight close-up photograph of black chrome finish on aluminum electronics module cover from experiment A0176 on tray F9.

LDEF location	%Fe	%O	%C	%Si	%F
Ground Control	-	12.05	80.78	1.51	-
Ground Control	-	12.17	81.10	1.50	-
Ground Control	-	11.91	81.22	2.50	-
Ground Control	-	12.30	78.83	1.46	-
F9	0.25	53.02	17.83	20.55	0.74
F9	-	49.91	22.17	19.52	0.58
E10	-	47.37	21.90	18.10	1.06
E10	-	47.05	23.10	18.19	1.02
E10	0.78	37.12	38.48	13.26	1.18
E10	0.57	38.86	34.92	14.47	1.09
D11	1.63	49.41	17.74	15.93	1.03
D11	2.89	44.18	17.20	16.22	2.16
B11	1.50	48.76	18.14	16.88	1.04
B11	1.14	48.70	19.06	17.54	0.94
A11	1.55	55.74	13.30	20.41	1.07
A11	2.81	51.66	15.44	22.70	0.84
A12	1.47	54.83	17.92	15.97	1.19
A12	1.72	54.08	17.96	15.96	1.20
G12	-	45.56	24.55	16.50	1.29
G12	-	46.08	25.01	16.55	1.07
H6	1.71	50.04	28.04	12.13	0.97
H6	1.12	46.76	28.27	14.80	1.05
B1	1.43	52.80	13.02	17.36	0.76
B1	2.00	54.04	12.61	17.51	0.94
F2	1.09	46.62	19.63	14.52	1.13
F2	0.99	49.69	21.92	17.50	0.79
D2	2.10	46.29	27.33	13.96	2.05
D2	0.84	46.97	26.62	16.12	2.16
F2	1.43	46.90	24.54	14.42	1.50
F2	1.53	47.54	21.94	16.40	1.59
C3	1.09	45.89	32.41	11.56	0.65
C3	1.25	46.37	33.04	12.06	0.54
C3	0.73	37.37	44.42	9.54	1.54
C3	-	29.74	55.25	5.65	1.31
E3	1.50	42.95	33.61	11.90	-
E3	1.48	45.89	29.26	13.67	-
D4	-	38.80	40.96	9.54	0.59
D4	-	37.62	41.72	8.85	-
E4	0.47	30.09	53.55	5.96	1.61
E4	0.50	29.16	54.65	6.22	1.53
C5	1.22	37.14	36.74	8.55	2.79
C5	1.20	41.80	28.26	14.07	2.88
D5	1.61	38.38	35.35	11.21	1.39
D5	1.29	40.01	35.35	10.58	1.45
B6	1.22	36.02	39.42	7.90	2.02
B6	0.58	30.67	49.25	6.36	1.70
B6	1.82	42.99	25.17	13.82	1.36

Table 4. Elemental %'s determined by ESCA for iron, silicon, oxygen, carbon, and fluorine on tray clamp bolt heads from LDEF.

LDEF location	%Fe	%O	%C	%Si	%F
B6	1.97	40.31	25.25	14.01	1.04
B6	0.51	44.38	35.01	2.22	1.11
F6	1.81	44.64	22.05	14.32	1.30
F6	1.49	47.73	25.07	12.41	1.20
F7	2.07	55.92	16.15	17.56	-
F7	2.77	52.87	16.67	18.35	-
E8	1.61	49.47	18.50	17.42	0.55
E8	2.65	47.10	16.61	17.60	-

Table 4 (continued). Elemental %'s determined by ESCA for iron, silicon, oxygen, carbon, and fluorine on tray clamp bolt heads from LDEF.

Figures 16 and 17 show the energy of ESCA peaks representative of silicon based compounds plotted against position on LDEF. Related auger spectra showing the depth profiles of silicon and other major species on the stainless steel bolt heads are contained in appendix F. "Rows" 13 and 14 are the Earth- and space-ends, respectively. Figure 16 shows values taken from survey spectra from stainless steel bolt heads, and while suggestive, the precision of this data is not sufficient to distinguish between silica and silicone species. Figure 17 shows results from high resolution data which does allow separation of "inorganic" and "organic" silicon containing species. The high resolution spectra from which this data was obtained are included in appendix G. This data was obtained from stainless steel bolts examined by Boeing and from aluminum tray clamp surfaces analyzed at Virginia Polytechnic Institute and State University (ref. 29). Control bolts show peaks at 103.5-104 eV, as expected for silicates. Control tray clamps showed slight amounts of Si present as silicone, with ESCA peaks at about 102.5 eV. The amount present on the control clamps is significantly less than the amounts on the flight hardware, and may represent the background level in the test chamber. Many of the tray clamps examined, particularly those from trailing edge locations, show silicone related peaks. Specimens from rows 7, 8, and 12 each show silicones present. One specimen from row 7, and specimens from rows 9, 10, and 11 indicate the presence of silicates. ESCA probes about a depth of 20 angstroms. The presence of silicones on leading edge surfaces indicate that this material was deposited at the very end of the mission, subsequent to any atomic oxygen exposure. This is significant because LDEF materials had 69 months to outgas prior to this occurrence and are not likely sources.

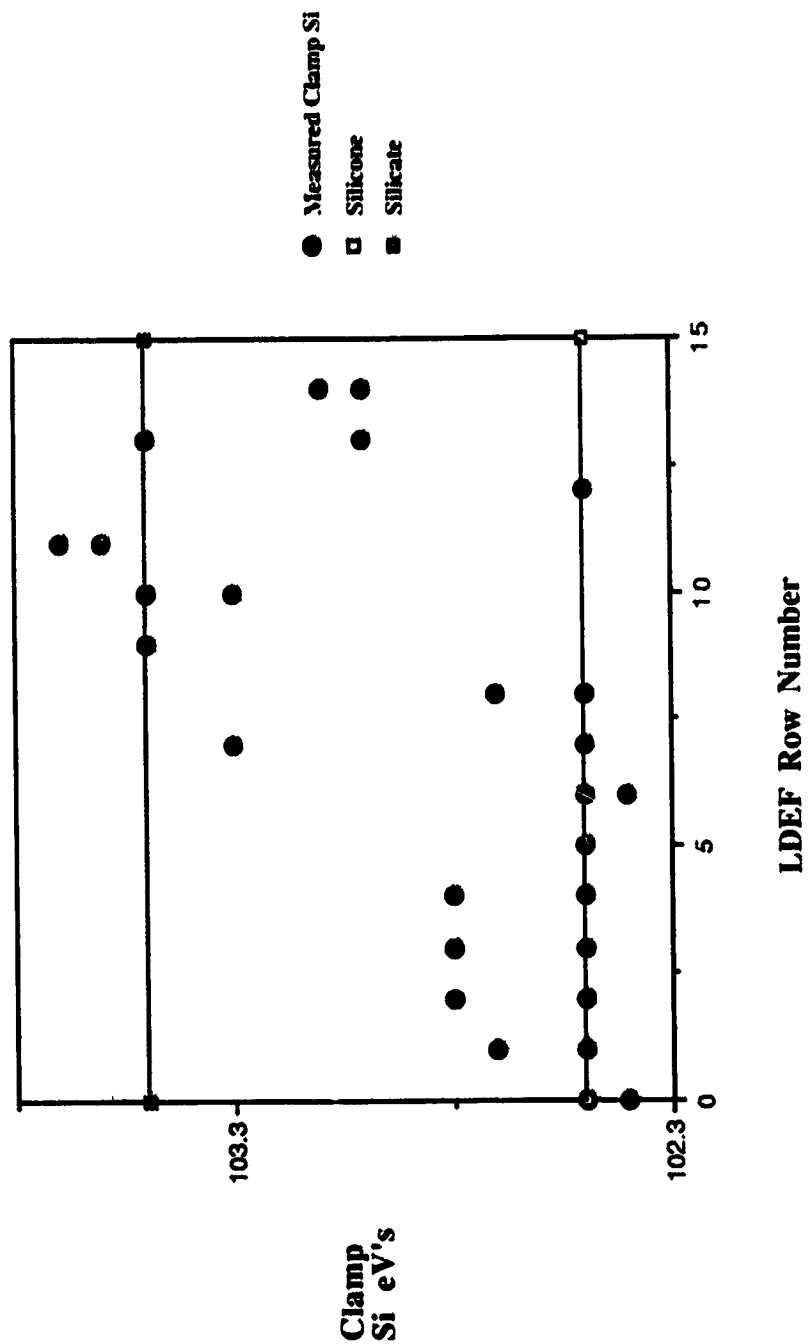


Figure 16. Surface analysis results from survey ESCA measurements on LDEF tray clamps.

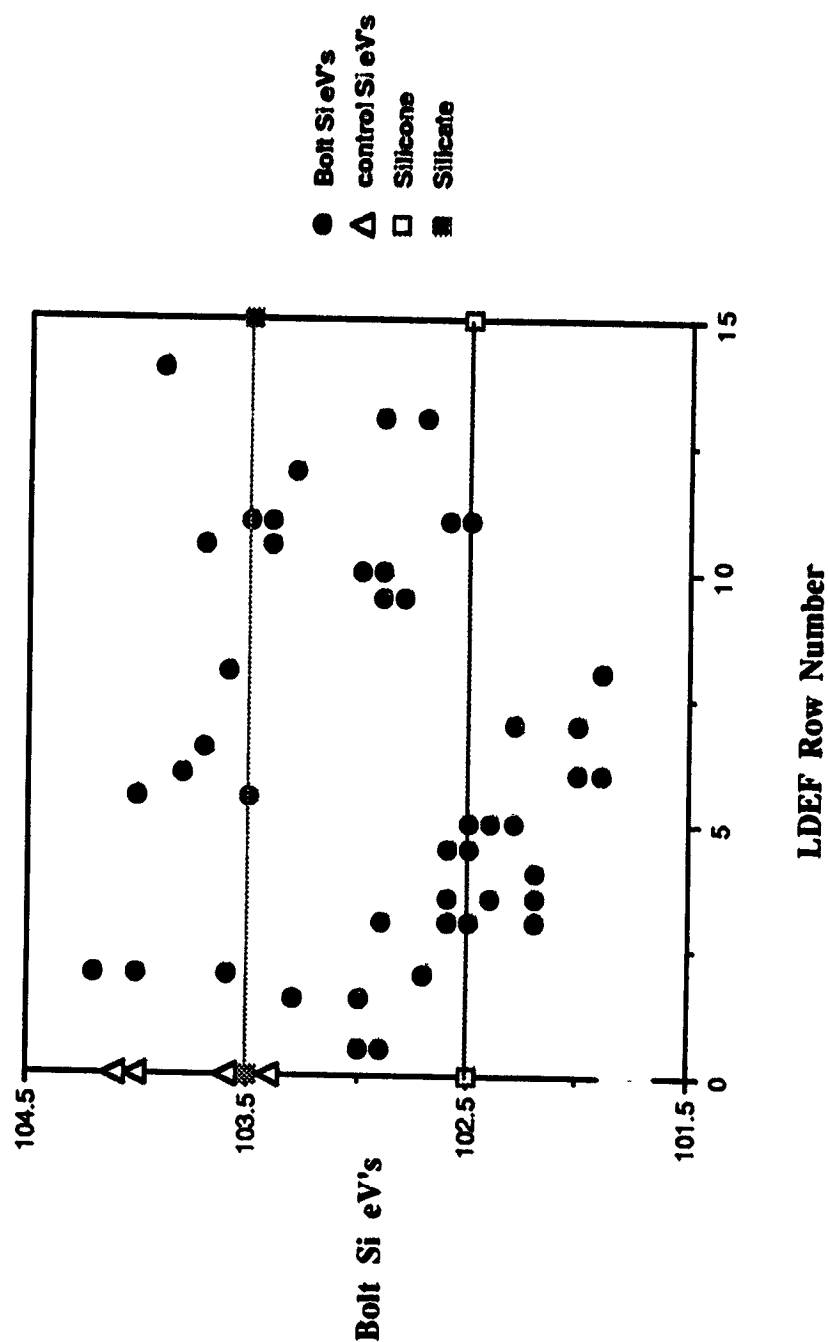


Figure 17. Results of high resolution ESCA measurements on selected stainless steel bolt heads from LDEF.

5.11 Tantalum, Tungsten, Zirconium

On tray D9, experiment M0002, a thin, porous layer of Ta_2O_5 was formed due to the exposure conditions. A mixture of at least four oxides were found on the tungsten specimen surface. The zirconium specimen on this experiment also formed a thin porous oxide layer during flight. Results are discussed further in reference 19, including a table of oxide thicknesses on each metal flown on this experiment. A portion of each specimen was shielded from direct exposure during flight by an aluminum bar, effectively creating an "internal standard" for each sample. Reflectance data for tantalum is published in reference 23.

5.12 Tin

Except for possible surface oxidation on the leading edge specimens, this material was unchanged. Trace amounts of contamination on all tin specimens from A0114 masked any effects on the metal itself.

5.13 Titanium

The titanium specimen flown on experiment A0171 was half-exposed and half-protected. Only slight changes in the optical properties were observed (ref. 23).

5.14 Platinum

No change in the properties of this material were observed. Extremely thin silicon based contamination was present on both specimens of this material flown on experiment A0114.

5.15 Textured Surfaces and Thin Coatings

Small variations in the thermal emittance of silicon and titanium coated specimens from the Ion Beam Textured and Coated Surfaces Experiment were observed as a result of exposure on row 6 of the LDEF (ref. 30). Copper showed a rather large change (0.50 to 0.69) in thermal emittance. Optical properties of Inconel, stainless steel, and black chrome specimens from the Ion Beam-Textured and Coated Surfaces (IBEX) experiment were virtually unchanged. Textured, "leafing aluminum" was used as an AO barrier for selected composite specimens from M0003. This material was virtually unchanged as a result of flight exposure.

6.0 Components

6.1 Primary Structure

The primary structure and structural fasteners have been examined and reported on by several groups (ref. 31). No changes due to the space environment exposure on LDEF have been found.

6.2 Cold Welding

Investigation of potential cold welding of metals in space was the subject of one part of the FRECOPA experiment, A0138, (refs. 32-33). The Systems Special Investigation Group also examined hardware for evidence of this phenomenon. Results of these investigations are presented in reference 34. No evidence of cold welding of metals was found on LDEF.

7.0 Summary

In summary, effects of exposure on metals ranged from essentially no effect, to surface color changes due to contamination deposits, to some degradation due to oxidation, to extreme damage and loss of material under atomic oxygen exposure.

Specific results, presented at the Third LDEF Post-Retrieval Symposium, are repeated below. Metals are highly variable in their response to the LEO environment. Gold and Platinum are nonreactive. Osmium forms a volatile oxide and is rapidly eroded under exposure to atomic oxygen. Silver, which forms a nonprotective oxide, is rapidly eroded. Other metals (Al, Cu, Ga, Ge, Ir, Mo, Ni, Ti, and Sn) show some level of reaction unless protected. Contamination is a major contributor to exposure effects on metal surfaces. Absorptance is significantly greater for bare aluminum than for CAA aluminum. Emittance is significantly less for aluminum than for CAA aluminum. The surface properties of both bare aluminum and CAA aluminum are little changed by exposure to LEO environmental conditions. Magnesium in aluminum alloys is preferentially oxidized relative to aluminum. An oxide coating forms on exposure of copper to atomic oxygen that impedes further oxidation. The oxide coating adversely affects the optical properties of copper. Copper without surface protection may be used for extended periods of time in applications where thermal management and optical performance requirements are not critical.

The changes to the metals are essentially due to surface or near-surface effects. For materials which form non-passivating oxides, the damage can be extensive over time.

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Appendix A

ESCA Spectra for selected bolts from a distribution of locations on the LDEF.

The nomenclature used to identify the location of the bolts investigated is bay (A-F), row(1-12)-tray clamp number (1-8), bolt (a, b, or c), measurement number (1 or 2). For Earth or space end clamps the designations are G or H respectively, followed by a location number (1-12) associated with a row.

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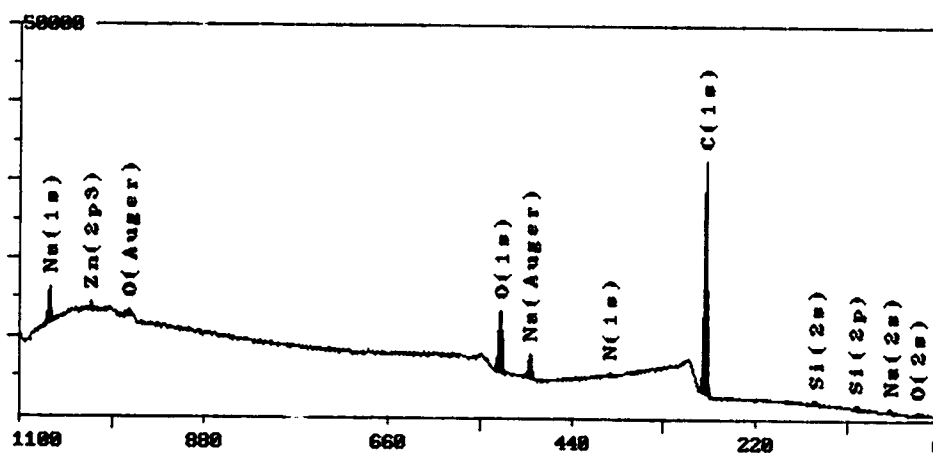
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Mon Oct 04 06:51:48 M-Probe ESCA Console User ID: JESSE
 CNTRL1_1.MRS Fri Oct 01 07:56:38 1993 Operator: Jesse Cherian
 LDEF - Stainless Steel Bolt
 Spot: 400x1000µ Resolution: 4 Energy:
 Scans: 20 of 20 Neutralizer: 0.1eV Counts:
 Region: 1/ 1 Aperture: None



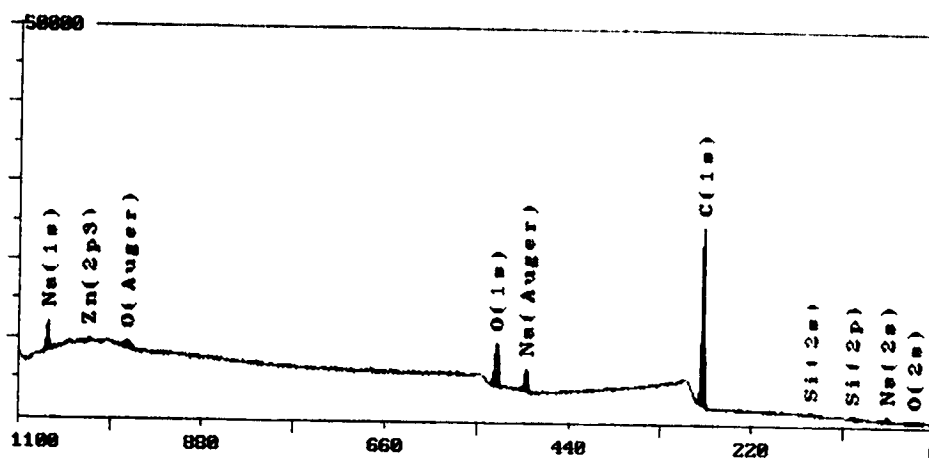
Surface Composition Table Summary

File name: CNTRL1_1.MRS
 Region: 1
 Description: LDEF - Stainless Steel Bolt
 Operator: Jesse Cherian
 Date: Fri Oct 1 07:56 1993

Element	Binding Energy	atom %
Na (1s)	1071.4	4.19
Zn (2p)	1022.1	0.66
O (1s)	531.7	12.05
N (1s)	399.1	0.82
C (1s)	284.6	80.78
Si (2p)	104.0	1.51

Figure A-1 Survey ESCA spectrum for stainless steel bolt, ground control 1, location 1.

Mon Oct 04 06:53:01 M-Probe ESCA Console User ID: JESSE
 CNTRL1_2.MRS Fri Oct 01 11:32:31 1993 Operator: Jesse Cherian
 LDEF - Stainless Steel Bolt
 Spot: 400x1000p Resolution: 4 Energy:
 Scans: 20 of 20 Neutralizer: 0.1eV Counts:
 Region: 1/ 1 Aperture: None



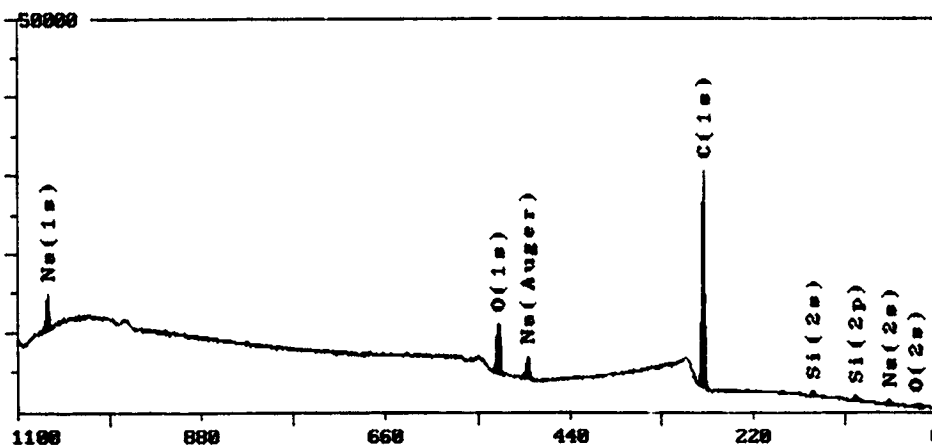
Surface Composition Table Summary

File name: CNTRL1_2.MRS
 Region: 1
 Description: LDEF - Stainless Steel Bolt
 Operator: Jesse Cherian
 Date: Fri Oct 1 11:32 1993

Element	Binding Energy	atom %
Na (1s)	1071.2	4.35
Zn (2p3)	1021.8	0.87
O (1s)	531.6	12.17
C (1s)	284.6	81.10
Si (2p)	104.1	1.50

Figure A-2 Survey ESCA spectrum for stainless steel bolt, ground control 1, location 2.

Mon Oct 04 06:51:10 M-Probe ESCA Console User ID: JESSE
 CNTRL2_1.MRS Fri Oct 01 13:20:58 1993 Operator: Jesse Cherian
 LDEF - Stainless Steel Bolt
 Spot: 400x1000µ Resolution: 4 Energy:
 Scans: 20 of 20 Neutralizer: 2.0eV Counts:
 Region: 1/ 1 Aperture: None



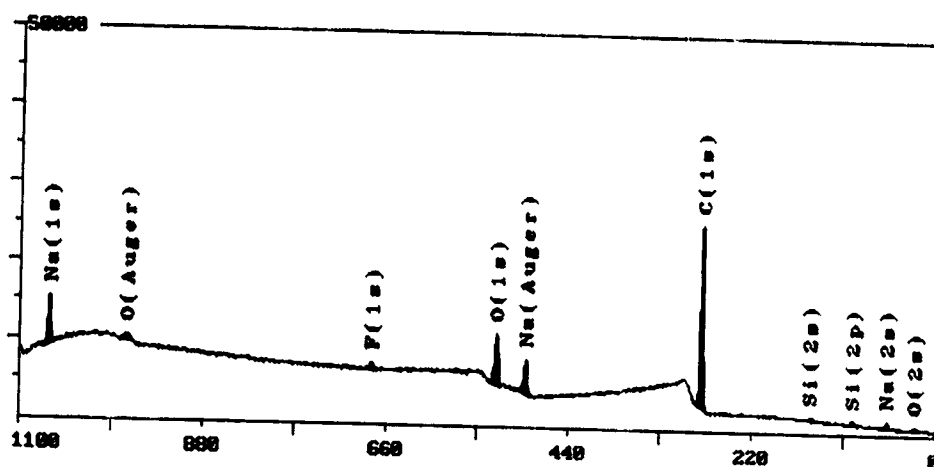
Surface Composition Table Summary

File name: CNTRL2_1.MRS
 Region: 1
 Description: LDEF - Stainless Steel Bolt
 Operator: Jesse Cherian
 Date: Fri Oct 1 13:20 1993

Element	Binding Energy	atom %
Na (1s)	1071.3	4.37
O (1s)	531.8	11.91
C (1s)	284.6	81.22
Si (2p)	103.4	2.50

Figure A-3 Survey ESCA spectrum for stainless steel bolt, ground control 2, location 1.

Mon Oct 04 06:50:01 M-Probe ESCA Console User ID: JESSE
 CNTRL2_2.MRS Sat Oct 02 06:26:35 1993 Operator: Jesse Cherian
 LDEF - Stainless Steel Bolt
 Spot: 400x1000p Resolution: 4 Energy:
 Scans: 20 of 20 Neutralizer: 2.0eV Counts:
 Region: 1/ 1 Aperture: None



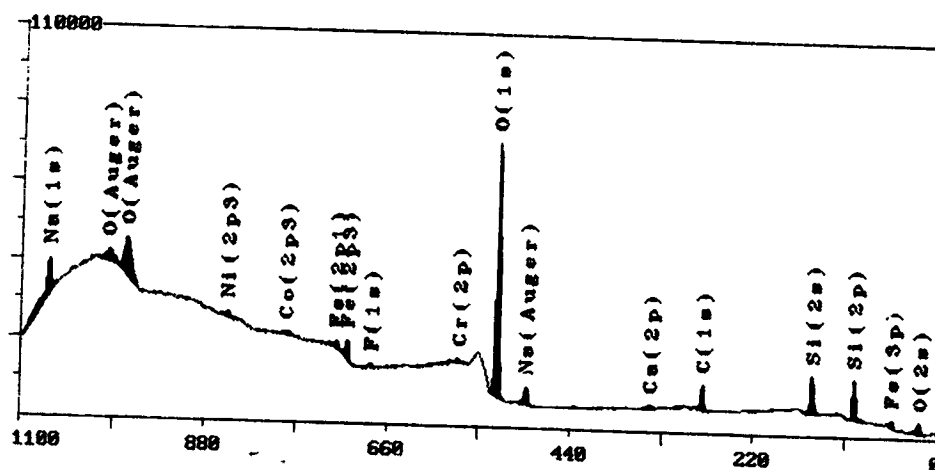
Surface Composition Table Summary

File name: CNTRL2_2.MRS
 Region: 1
 Description: LDEF - Stainless Steel Bolt
 Operator: Jesse Cherian
 Date: Sat Oct 2 06:26 1993

Element	Binding Energy	atom %
Na (1s)	1071.3	6.33
F (1s)	683.4	1.03
O (1s)	531.5	12.30
C (1s)	284.6	78.83
Si (2p)	103.6	1.46

Figure A-4 Survey ESCA spectrum for stainless steel bolt, ground control 2, location 2.

Thu Aug 12 09:06:52 M-Probe ESCA Console User ID: JESSE
 B012B_1.MRS Wed Aug 11 09:44:15 1993 Operator: Jesse Cherian
 LDEF - Stainless Steel Bolt
 Spot: 400x1000µ Resolution: 4
 Scans: 20 of 20 Neutralizer: 0.1eV Energy:
 Region: 1/ 1 Aperture: None Counts:



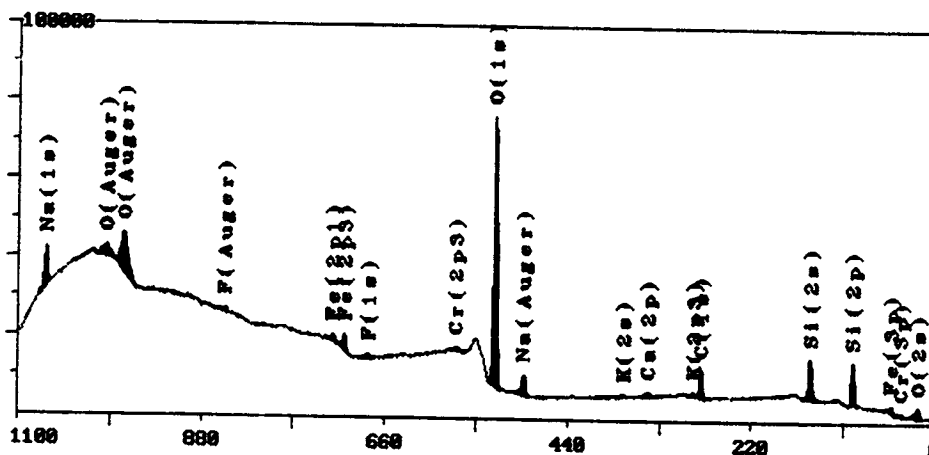
Surface Composition Table Summary

File name: B012B_1.MRS
 Region: 1
 Description: LDEF - Stainless Steel Bolt
 Operator: Jesse Cherian
 Date: Wed Aug 11 09:44 1993

Element	Binding Energy	atom %
Na (1s)	1071.3	12.85
Ni (2p3)	857.5	0.37
Co (2p3)	776.3	0.68
Fe (2p3)	712.5	1.43
F (1s)	685.3	0.76
Cr (2p)	578.0	0.27
O (1s)	532.3	52.80
Ca (2p)	348.3	0.45
C (1s)	284.6	13.02
Si (2p)	102.0	17.35

Figure A-5 Survey ESCA spectrum for stainless steel bolt B1, 2b-1.

Thu Aug 12 09:12:58 M-Probe ESCA Console User ID: JESSE
 B012B_2.MRS Wed Aug 11 11:14:03 1993 Operator: Jesse Cherian
 LDEF - Stainless Steel Bolt
 Spot: 400x1000p Resolution: 4 Energy:
 Scans: 20 of 20 Neutralizer: 0.1eV Counts:
 Region: 1/ 1 Aperture: None



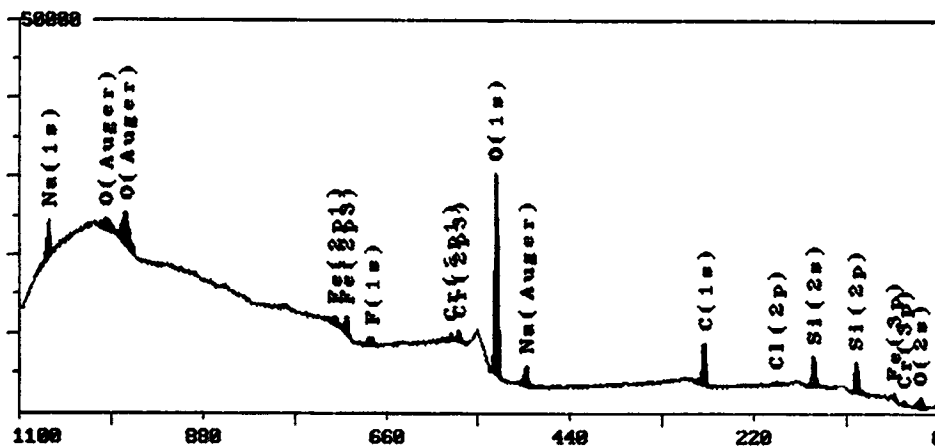
Surface Composition Table Summary

File name: B012B_2.MRS
 Region: 1
 Description: LDEF - Stainless Steel Bolt
 Operator: Jesse Cherian
 Date: Wed Aug 11 11:14 1993

Element	Binding Energy	atom %
Na (1s)	1071.1	11.44
Fe (2p3)	712.9	2.00
F (1s)	685.0	0.94
Cr (2p3)	579.0	0.34
O (1s)	532.4	54.04
Ca (2p)	348.2	0.52
K (2p3)	293.5	0.60
C (1s)	284.6	12.61
Si (2p)	103.0	17.51

Figure A-6 Survey ESCA spectrum for stainless steel bolt B1, 2b-2.

Mon Oct 04 11:48:24 M-Probe ESCA Console User ID: JESSE
 D024C_01.MRS Sat Oct 02 12:04:15 1993 Operator: Jesse Cherian
 LDEF - Stainless Steel Bolt
 Spot: 400x1000µ Resolution: 4 Energy:
 Scans: 20 of 20 Neutralizer: 0.1eV Counts:
 Region: 1/ 1 Aperture: None



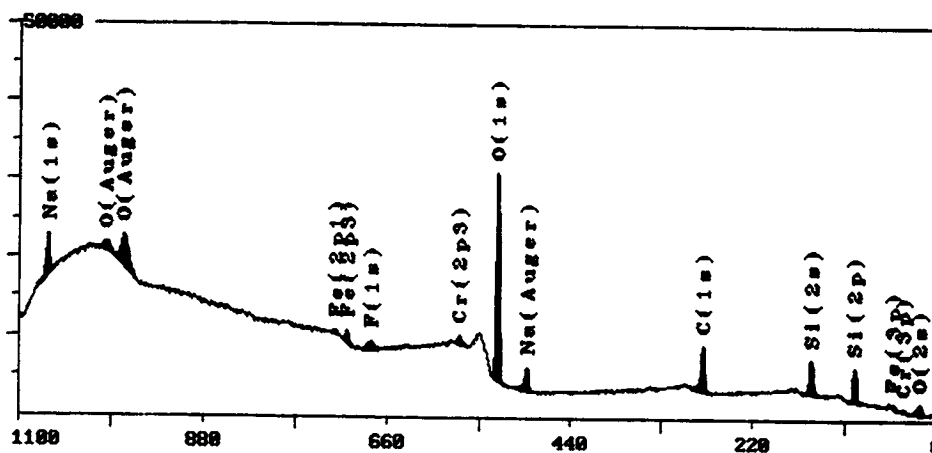
Surface Composition Table Summary

File name: D024C_01.MRS
 Region: 1
 Description: LDEF - Stainless Steel Bolt
 Operator: Jesse Cherian
 Date: Sat Oct 2 12:04 1993

Element	Binding Energy	atom %
Na (1s)	1070.9	6.89
Fe (2p3)	713.6	2.10
F (1s)	683.3	2.05
Cr (2p3)	579.0	0.77
O (1s)	533.3	46.29
C (1s)	284.6	27.33
Cl (2p)	197.9	0.62
Si (2p)	104.0	13.96

Figure A-7 Survey ESCA spectrum for stainless steel bolt D2, 4c-1.

Mon Oct 04 12:04:52 M-Probe ESCA Console User ID: JESSE
 D024C_02.MRS Sat Oct 02 13:08:55 1993 Operator: Jesse Cherian
 LDEF - Stainless Steel Bolt
 Spot: 400x1000µ Resolution: 4 Energy:
 Scans: 20 of 20 Neutralizer: 0.1eV Counts:
 Region: 1/ 1 Aperture: None



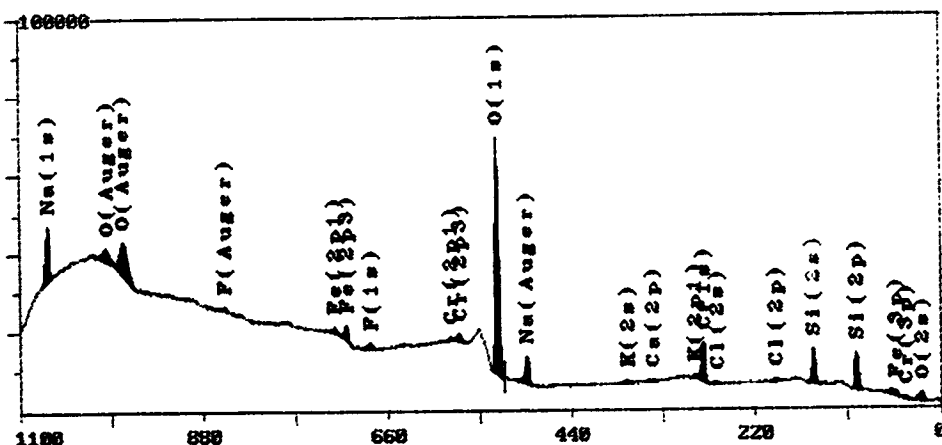
Surface Composition Table Summary

File name: D024C_02.MRS
 Region: 1
 Description: LDEF - Stainless Steel Bolt
 Operator: Jesse Cherian
 Date: Sat Oct 2 13:08 1993

Element	Binding Energy	atom %
Na (1s)	1071.0	6.59
Fe (2p3)	713.4	0.84
F (1s)	683.9	2.16
Cr (2p3)	578.9	0.70
O (1s)	533.0	46.97
C (1s)	284.6	26.62
Si (2p)	103.6	16.12

Figure A-8 Survey ESCA spectrum for stainless steel bolt D2, 4c-2.

Mon Sep 13 11:14:05 M-Probe ESCA Console User ID: JESSE
 F022C_01.MRS Fri Sep 10 13:51:17 1993 Operator: Jesse Cherian
 LDEF - Stainless Steel Bolt
 Spot: 400x1000p Resolution: 4 Energy: 521.40 eV
 Scans: 20 of 20 Neutralizer: 0.1eV Counts: 8004
 Region: 1/ 1 Aperture: None



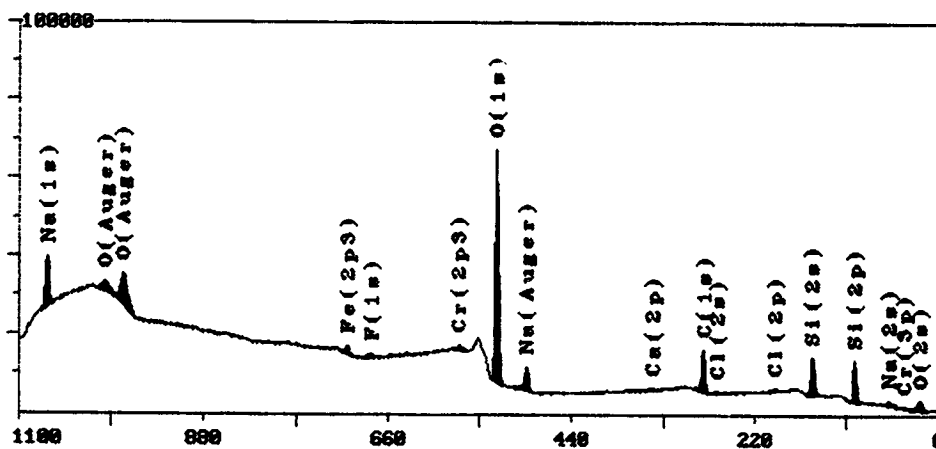
Surface Composition Table Summary

File name: F022C_01.MRS
 Region: 1
 Description: LDEF - Stainless Steel Bolt
 Operator: Jesse Cherian
 Date: Fri Sep 10 13:51 1993

Element	Binding Energy	atom %
Na (1s)	1071.0	14.63
Fe (2p3)	712.8	1.09
F (1s)	684.2	1.13
Cr (2p3)	577.8	0.63
O (1s)	532.8	40.62
Ca (2p)	340.7	0.22
K (2p1)	294.3	0.94
C (1s)	284.6	19.63
Cl (2p)	199.1	0.59
Si (2p)	103.3	14.52

Figure A-9 Survey ESCA spectrum for stainless steel bolt F2, 2c-1.

Mon Sep 13 06:18:12 M-Probe ESCA Console User ID: JESSE
 F022C_02.MRS Fri Sep 10 14:55:57 1993 Operator: Jesse Cherian
 LDEF - Stainless Steel Bolt
 Spot: 488x1000µ Resolution: 4 Energy:
 Scans: 20 of 20 Neutralizer: 0.1eV Counts:
 Region: 1/ 1 Aperture: None



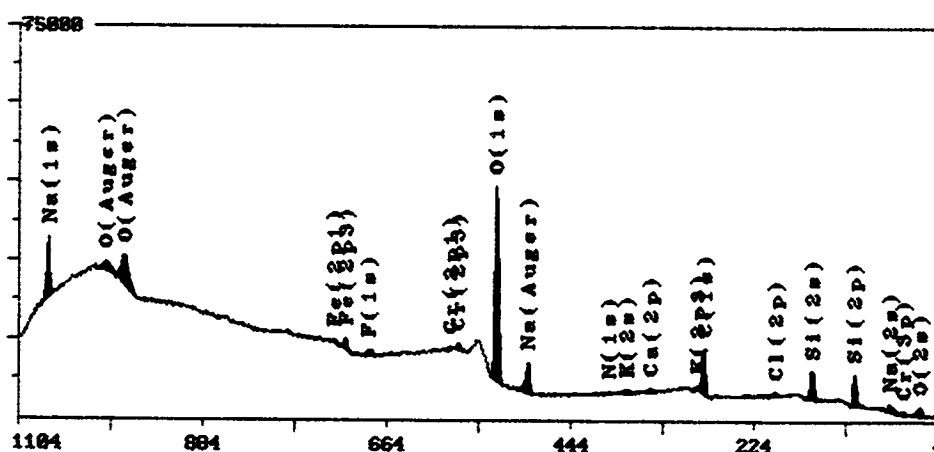
Surface Composition Table Summary

File name: F022C_02.MRS
 Region: 1
 Description: LDEF - Stainless Steel Bolt
 Operator: Jesse Cherian
 Date: Fri Sep 10 14:55 1993

Element	Binding Energy	atom %
Na (1s)	1071.1	8.02
Fe (2p3)	712.4	0.99
F (1s)	684.3	0.79
Cr (2p3)	577.8	0.48
O (1s)	532.5	49.69
C (1s)	284.6	21.92
Cl (2p)	198.7	0.61
Si (2p)	103.0	17.50

Figure A-10 Survey ESCA spectrum for stainless steel bolt F2, 2c-2.

Thu Sep 16 11:11:28 M-Probe ESCA Console User ID: JESSE
 F028B_01.MRS Mon Sep 13 10:44:43 1993 Operator: Jesse Cherian
 LDEF - Stainless Steel Bolt
 Spot: 400x1000µ Resolution: 4 Energy:
 Scans: 20 of 20 Neutralizer: 0.1eV Counts:
 Region: 1/ 1 Aperture: None



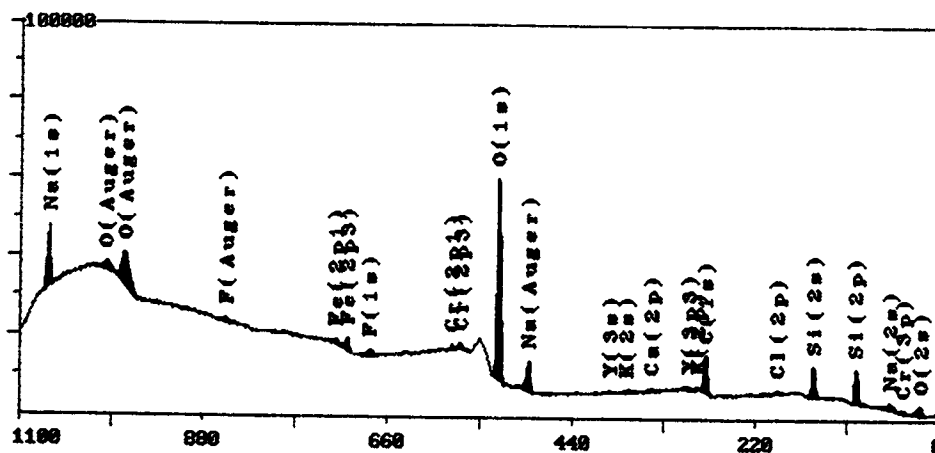
Surface Composition Table Summary

File name: F028B_01.MRS
 Region: 1
 Description: LDEF - Stainless Steel Bolt
 Operator: Jesse Cherian
 Date: Mon Sep 13 10:44 1993

Element	Binding Energy	atom %
Na (1s)	1071.2	8.06
Fe (2p3)	713.9	1.43
F (1s)	687.3	1.50
Cr (2p3)	579.5	0.48
O (1s)	533.8	46.90
N (1s)	399.0	0.71
Ca (2p)	349.3	0.33
K (2p3)	292.6	0.70
C (1s)	284.6	24.54
Cl (2p)	198.9	0.92
Si (2p)	104.2	14.42

Figure A-11 Survey ESCA spectrum for stainless steel bolt F2, 8b-1.

Fri Sep 10 10:02:23 M-Probe ESCA Console User ID: JESSE
 F028B_02.MRS Fri Sep 10 09:28:58 1993 Operator: Jesse Cherian
 LDEF - Stainless Steel Bolt
 Spot: 400x1000p Resolution: 4 Energy:
 Scans: 20 of 20 Neutralizer: 0.1eV Counts:
 Region: 1/ 1 Aperture: None



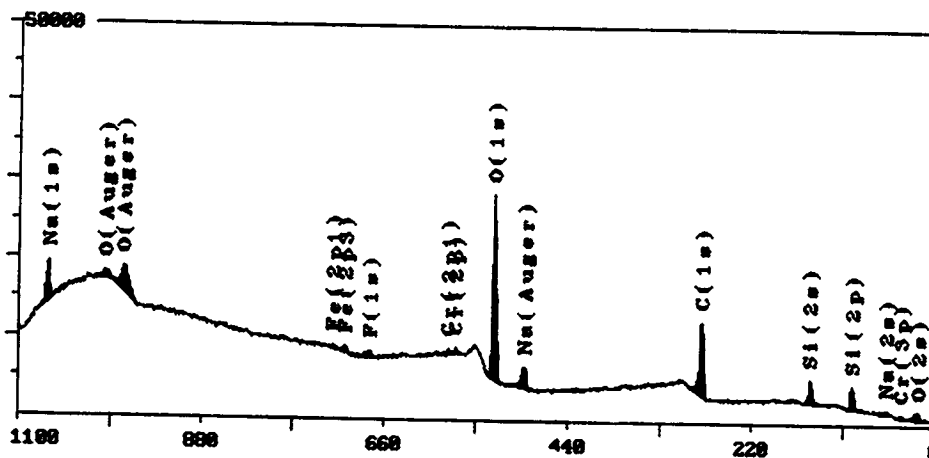
Surface Composition Table Summary

File name: F028B_02.MRS
 Region: 1
 Description: LDEF - Stainless Steel Bolt
 Operator: Jesse Cherian
 Date: Fri Sep 10 09:28 1993

Element	Binding Energy	atom %
Na (1s)	1070.0	8.76
Fe (2p3)	712.2	1.53
F (1s)	685.4	1.59
Cr (2p3)	577.8	0.60
O (1s)	532.0	47.54
Ca (2p)	348.0	0.37
Y (3p3)	304.7	0.36
K (2p)	294.0	0.21
C (1s)	284.6	21.94
Cl (2p)	197.0	0.70
Si (2p)	102.7	16.40

Figure A-12 Survey ESCA spectrum for stainless steel bolt F2, 8b-2.

Mon Oct 04 10:47:46 M-Probe ESCA Console User ID: JESSE
 C038A_01.MRS Sat Oct 02 09:54:53 1993 Operator: Jesse Cherian
 LDEF - Stainless Steel Bolt
 Spot: 400x1000µ Resolution: 4 Energy:
 Scans: 20 of 20 Neutralizer: 0.1eV Counts:
 Region: 1/ 1 Aperture: None



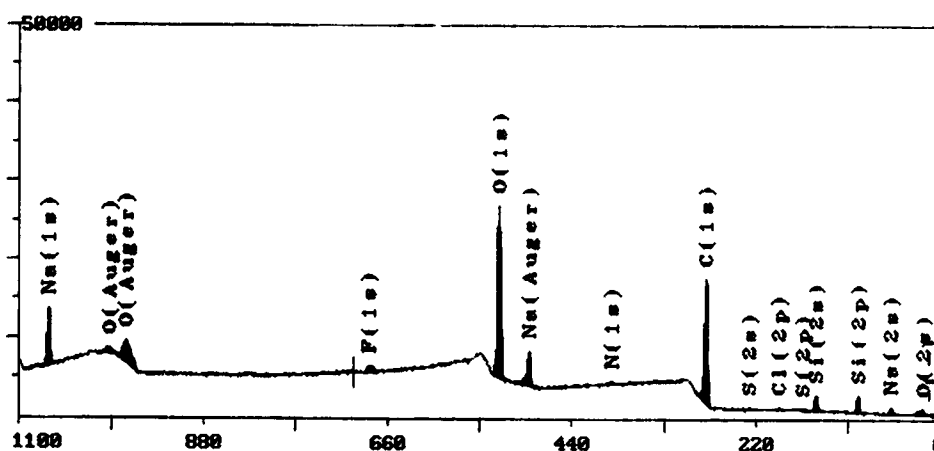
Surface Composition Table Summary

File name: C038A_01.MRS
 Region: 1
 Description: LDEF - Stainless Steel Bolt
 Operator: Jesse Cherian
 Date: Sat Oct 2 09:54 1993

Element	Binding Energy	atom %
Na (1s)	1069.8	6.23
Fe (2p3)	712.4	0.73
F (1s)	681.8	1.54
Cr (2p)	577.9	0.17
O (1s)	532.4	37.37
C (1s)	284.6	44.42
Si (2p)	102.9	9.54

Figure A-13 Survey ESCA spectrum for stainless steel bolt C3, 8a-1.

Mon Oct 04 10:52:06 M-Probe ESCA Console User ID: JESSE
 C038A_02.MRS Sat Oct 02 10:59:34 1993 Operator: Jesse Cherian
 LDEF - Stainless Steel Bolt
 Spot: 400x1000µ Resolution: 4 Energy: 701.07 eV
 Scans: 20 of 20 Neutralizer: 0.1eV Counts: 5654
 Region: 1/ 1 Aperture: None



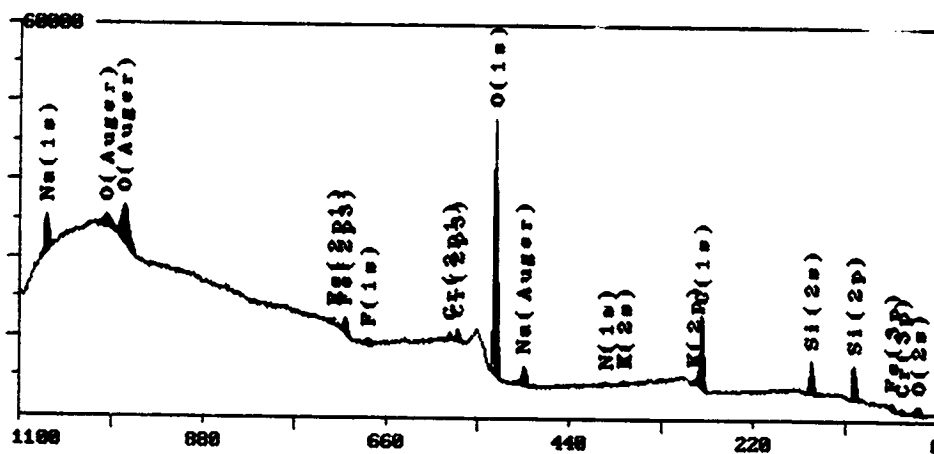
Surface Composition Table Summary

File name: C038A_02.MRS
 Region: 1
 Description: LDEF - Stainless Steel Bolt
 Operator: Jesse Cherian
 Date: Sat Oct 2 10:59 1993

Element	Binding Energy	atom %
Na (1s)	1071.2	6.67
F (1s)	687.6	1.31
O (1s)	531.9	29.74
N (1s)	398.6	0.63
C (1s)	284.6	55.25
Cl (2p)	197.5	0.22
S (2p)	169.4	0.54
Si (2p)	102.2	5.65

Figure A-14 Survey ESCA spectrum for stainless steel bolt C3, 8a-2.

Wed Aug 11 08:57:06 M-Probe ESCA Console User ID: JESSE
 C38B_1.MRS Tue Aug 10 13:35:12 1993 Operator: Jesse Cherian
 LDEF - Stainless Steel Bolt
 Spot: 400x1000µ Resolution: 4 Energy:
 Scans: 20 of 20 Neutralizer: 8.1eV Counts:
 Region: 1/ 1 Aperture: None



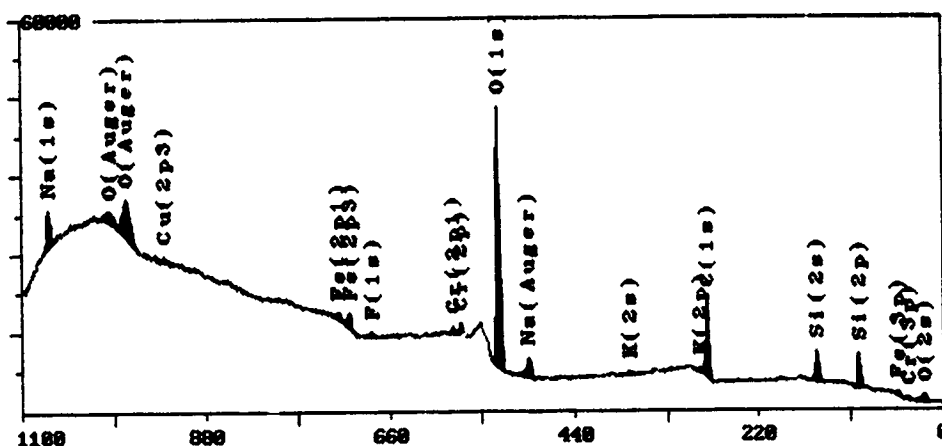
Surface Composition Table Summary

File name: C38B_1.MRS
 Region: 1
 Description: LDEF - Stainless Steel Bolt
 Operator: Jesse Cherian
 Date: Tue Aug 10 13:35 1993

Element	Binding Energy	atom %
Na (1s)	1071.7	5.75
Fe (2p3)	712.2	1.09
F (1s)	684.6	0.65
Cr (2p3)	576.9	0.80
O (1s)	532.1	45.89
N (1s)	399.2	0.93
Si (2p)	102.5	11.56
K (2p)	293.8	0.93
C (1s)	285.0	32.41

Figure A-15 Survey ESCA spectrum for stainless steel bolt C3, 8b-1.

Wed Aug 11 09:23:47 M-Probe ESCA Console User ID: JESSE
 C38B_2.MRS Tue Aug 10 14:41:23 1993 Operator: Jesse Cherian
 LDEF - Stainless Steel Bolt
 Spot: 400x1000µ Resolution: 4 Energy:
 Scans: 20 of 20 Neutralizer: 0.1eV Counts:
 Region: 1/ 1 Aperture: None



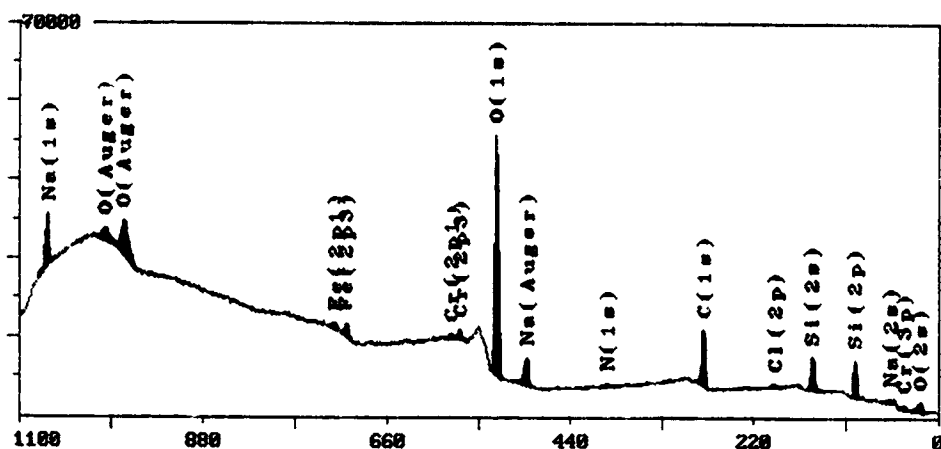
Surface Composition Table Summary

File name: C38B_2.MRS
 Region: 1
 Description: LDEF - Stainless Steel Bolt
 Operator: Jesse Cherian
 Date: Tue Aug 10 14:41 1993

Element	Binding Energy	atom %
Na (1s)	1071.8	5.28
Cu (2p ₃)	933.0	0.62
Fe (2p ₃)	711.7	1.25
F (1s)	685.2	0.54
Cr (2p)	577.0	0.57
O (1s)	532.3	46.37
K (2p)	293.3	0.26
C (1s)	284.6	33.04
Si (2p)	102.6	12.06

Figure A-16 Survey ESCA spectrum for stainless steel bolt C3, 8b-2.

Thu Aug 12 16:21:17 M-Probe ESCA Console User ID: JESSE
 E3SB_1.MRS Thu Aug 12 16:11:14 1993 Operator: Jesse Cherian
 LDEF - Stainless Steel Bolt
 Spot: 400x1000µ Resolution: 4 Energy:
 Scans: 20 of 20 Neutralizer: 0.1eV Counts:
 Region: 1/ 1 Aperture: None



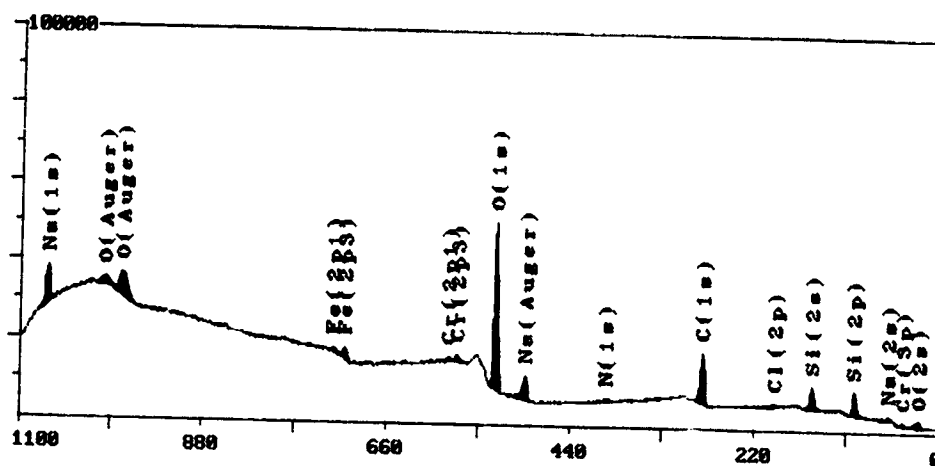
Surface Composition Table Summary

File name: E3SB_1.MRS
 Region: 1
 Description: LDEF - Stainless Steel Bolt
 Operator: Jesse Cherian
 Date: Thu Aug 12 16:11 1993

Element	Binding Energy	atom %
Na (1s)	1070.0	7.89
Fe (2p3)	712.8	1.48
Cr (2p3)	577.6	0.73
O (1s)	532.3	45.89
N (1s)	399.5	0.73
C (1s)	284.6	29.26
Cl (2p)	197.7	0.34
Si (2p)	102.6	13.67

Figure A-17 Survey ESCA spectrum for stainless steel bolt E3, 5b-1.

Tue Aug 17 13:03:28 M-Probe ESCA Console User ID: JESSE
 E35B_2.MRS Tue Aug 17 09:34:29 1993 Operator: Jesse Cherian
 LDEF - Stainless Steel Bolt
 Spot: 400x1000µ Resolution: 4
 Scans: 20 of 20 Neutralizer: 0.1eV Energy:
 Region: 1/ 1 Aperture: None Counts:



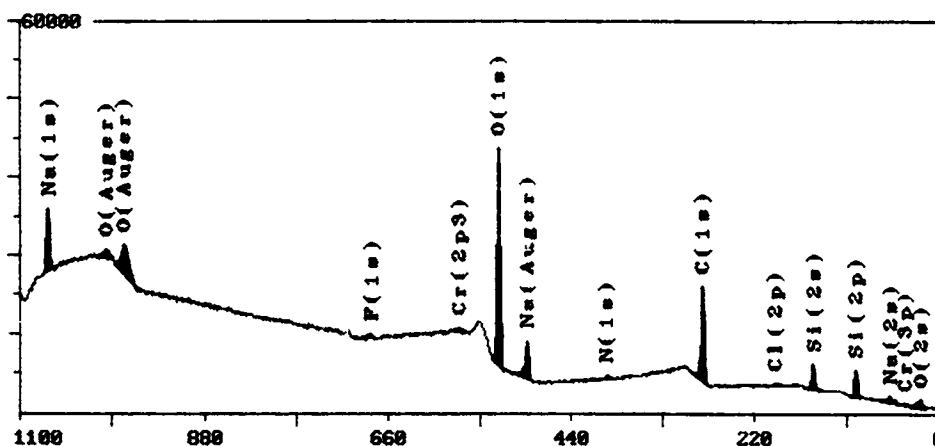
Surface Composition Table Summary

File name: E35B_2.MRS
 Region: 1
 Description: LDEF - Stainless Steel Bolt
 Operator: Jesse Cherian
 Date: Tue Aug 17 09:34 1993

Element	Binding Energy	atom %
Na (1s)	1069.7	7.68
Fe (2p3)	712.0	1.50
Cr (2p3)	577.6	0.63
O (1s)	531.9	42.95
N (1s)	399.3	0.93
C (1s)	284.6	33.61
Cl (2p)	197.4	0.80
Si (2p)	102.4	11.90

Figure A-18 Survey ESCA spectrum for stainless steel bolt E3, 5b-2.

Tue Aug 10 08:32:51 M-Probe ESCA Console User ID: JESSE
 D042B_1.MRS Tue Aug 10 07:40:04 1993 Operator: Jesse Cherian
 LDEF - Stainless Steel Bolt
 Spot: 400x1000µ Resolution: 4 Energy:
 Scans: 20 of 20 Neutralizer: 0.1eV Counts:
 Region: 1/ 1 Aperture: None



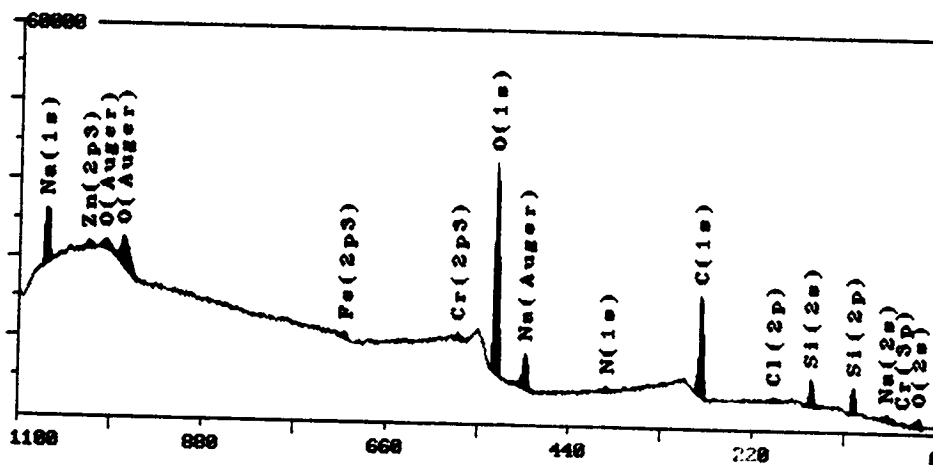
Surface Composition Table Summary

File name: D042B_1.MRS
 Region: 1
 Description: LDEF - Stainless Steel Bolt
 Operator: Jesse Cherian
 Date: Tue Aug 10 07:40 1993

Element	Binding Energy	atom %
Na (1s)	1071.1	8.46
F (1s)	684.3	0.59
Cr (2p3)	577.7	0.37
O (1s)	531.8	38.80
N (1s)	400.5	0.92
C (1s)	284.6	40.96
Cl (2p)	198.3	0.36
Si (2p)	102.2	9.54

Figure A-19 Survey ESCA spectrum for stainless steel bolt D4, 2b-1.

Wed Aug 11 09:13:52 M-Probe ESCA Console User ID: JESSE
D042B_2.MRS Tue Aug 10 08:48:53 1993 Operator: Jesse Cherian
LDEF - Stainless Steel Bolt
Spot: 400:000µ Resolution: 4 Energy:
Scans: 20 of 20 Neutralizer: 0.1eV Counts:
Region: 1/ 1 Aperture: None



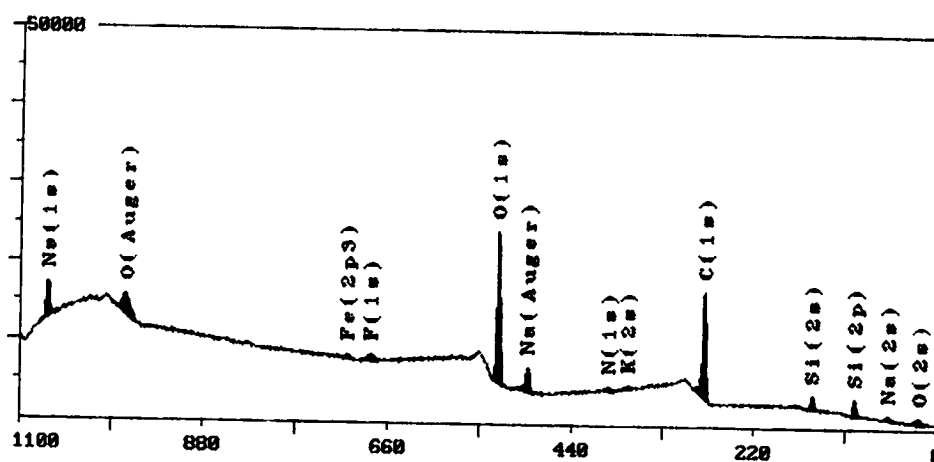
Surface Composition Table Summary

File name: D042B_2.MRS
Region: 1
Description: LDEF - Stainless Steel Bolt
Operator: Jesse Cherian
Date: Tue Aug 10 08:48 1993

Element	Binding Energy	atom %
Na (1s)	1071.3	8.56
Zn (2p3)	1021.6	1.36
Cr (2p3)	577.5	0.42
O (1s)	531.8	37.62
N (1s)	398.1	1.03
C (1s)	284.6	41.72
Cl (2p)	197.8	0.44
Si (2p)	102.2	8.85

Figure A-20 Survey ESCA spectrum for stainless steel bolt D4, 2b-2.

Mon Oct 04 07:04:40 M-Probe ESCA Console User ID: JESSE
 E047C_01.MRS Sat Oct 02 07:45:31 1993 Operator: Jesse Cherian
 LDEF - Stainless Steel Bolt
 Spot: 400x1000µ Resolution: 4 Energy:
 Scans: 20 of 20 Neutralizer: 0.1eV Counts:
 Region: 1/ 1 Aperture: None



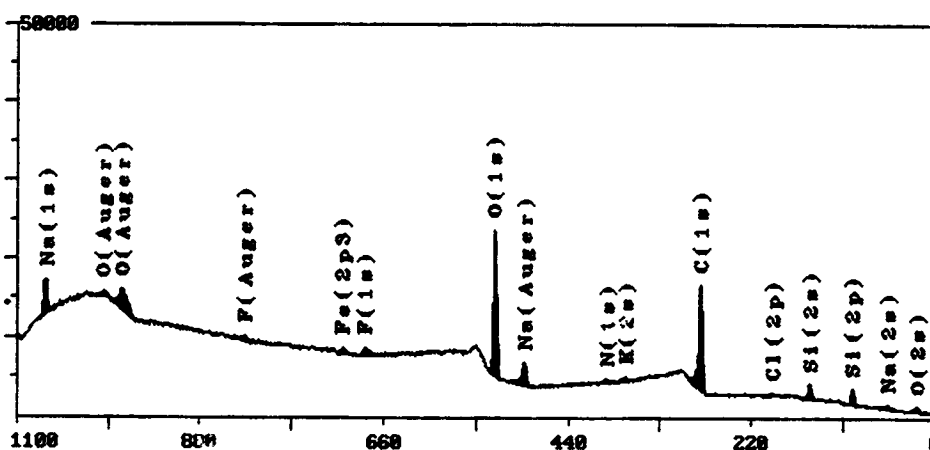
Surface Composition Table Summary

File name: E047C_01.MRS
 Region: 1
 Description: LDEF - Stainless Steel Bolt
 Operator: Jesse Cherian
 Date: Sat Oct 2 07:45 1993

Element	Binding Energy	atom %
Na (1s)	1071.2	6.37
Fe (2p3)	713.7	0.47
F (1s)	685.2	1.61
O (1s)	531.9	30.09
N (1s)	399.0	0.90
K (2s)	376.1	1.05
C (1s)	284.6	53.55
Si (2p)	102.6	5.96

Figure A-21 Survey ESCA spectrum for stainless steel bolt E4, 7c-1.

Mon Oct 04 10:45:31 M-Probe ESCA Console User ID: JESSE
 E047C_02.MRS Sat Oct 02 08:50:12 1993 Operator: Jesse Cherian
 LDEF - Stainless Steel Bolt
 Spot: 480x1000p Resolution: 4 Energy:
 Scans: 28 of 28 Neutralizer: 8.1eV Counts:
 Region: 1/ 1 Aperture: None



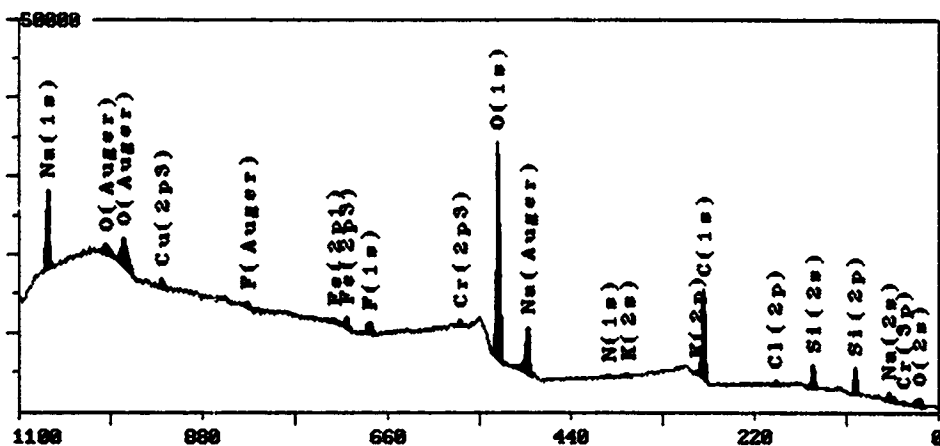
Surface Composition Table Summary

File name: E047C_02.MRS
 Region: 1
 Description: LDEF - Stainless Steel Bolt
 Operator: Jesse Cherian
 Date: Sat Oct 2 08:50 1993

Element	Binding Energy	atom %
Na (1s)	1069.9	5.67
Fe (2p3)	712.9	0.50
F (1s)	686.5	1.53
O (1s)	531.9	29.16
N (1s)	398.4	0.93
K (2s)	374.6	1.04
C (1s)	284.6	54.65
Cl (2p)	197.7	0.32
Si (2p)	102.5	6.22

Figure A-22 Survey ESCA spectrum for stainless steel bolt E4, 7c-2.

Thu Aug 12 14:02:38 M-Probe ESCA Console User ID: JESSE
 CS4B_1.MRS Thu Aug 12 13:53:19 1993 Operator: Jesse Cherian
 LDEF - Stainless Steel Bolt
 Spot: 480x1000p Resolution: 4 Energy:
 Scans: 20 of 20 Neutralizer: 0.1eV Counts:
 Region: 1/ 1 Aperture: None



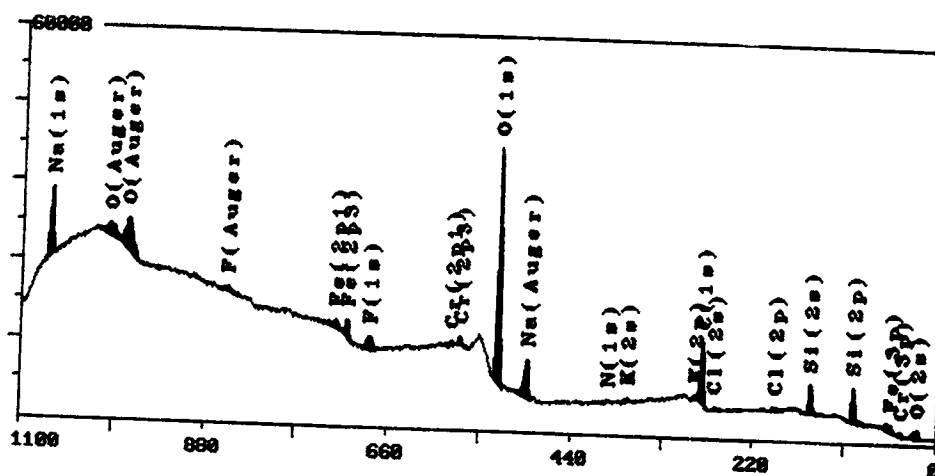
Surface Composition Table Summary

File name: C54B_1.MRS
 Region: 1
 Description: LDEF - Stainless Steel Bolt
 Operator: Jesse Cherian
 Date: Thu Aug 12 13:53 1993

Element	Binding Energy	atom %
Na (1s)	1070.1	10.02
Cu (2p3)	932.6	0.99
Fe (2p3)	711.9	1.22
F (1s)	685.5	2.79
Cr (2p3)	577.4	0.25
O (1s)	531.8	37.14
N (1s)	398.3	0.99
C (1s)	284.6	36.74
Cl (2p)	198.6	0.48
Si (2p)	102.4	8.55
K (2p)	293.2	0.83

Figure A-23 Survey ESCA spectrum for stainless steel bolt C5, 4b-1.

Thu Aug 12 15:16:56 M-Probe ESCA Console User ID: JESSE
 C54B_2.MRS Thu Aug 12 15:02:18 1993 Operator: Jesse Cherian
 LDEF - Stainless Steel Bolt
 Spot: 400x1000µ Resolution: 4
 Scans: 20 of 20 Neutralizer: 8.1eV Energy:
 Region: 1/ 1 Aperture: None Counts:



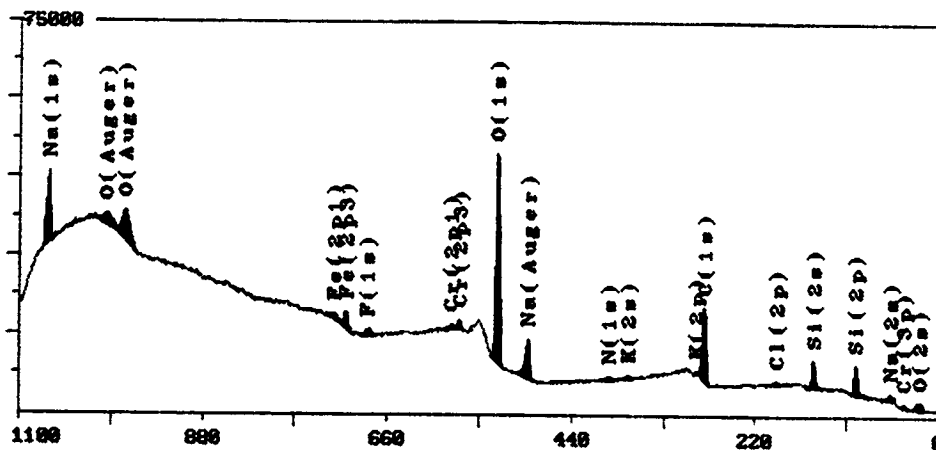
Surface Composition Table Summary

File name: C54B_2.MRS
 Region: 1
 Description: LDEF - Stainless Steel Bolt
 Operator: Jesse Cherian
 Date: Thu Aug 12 15:02 1993

Element	Binding Energy	atom %
Na (1s)	1069.7	9.26
Fe (2p3)	712.3	1.20
F (1s)	685.5	2.88
Cr (2p3)	577.4	0.51
O (1s)	531.7	41.80
N (1s)	398.7	0.93
K (2p)	293.2	0.19
C (1s)	284.6	28.26
Cl (2p)	197.0	0.91
Si (2p)	102.3	14.07

Figure A-24 Survey ESCA spectrum for stainless steel bolt C5, 4b-2.

Fri Sep 10 11:45:02 M-Probe ESCA Console User ID: JESSE
 D058C_01.MRS Fri Sep 10 11:40:10 1993 Operator: Jesse Cherian
 LDEF - Stainless Steel Bolt
 Spot: 400x1000µ Resolution: 4 Energy:
 Scans: 20 of 20 Neutralizer: 0.1eV Counts:
 Region: 1/ 1 Aperture: None



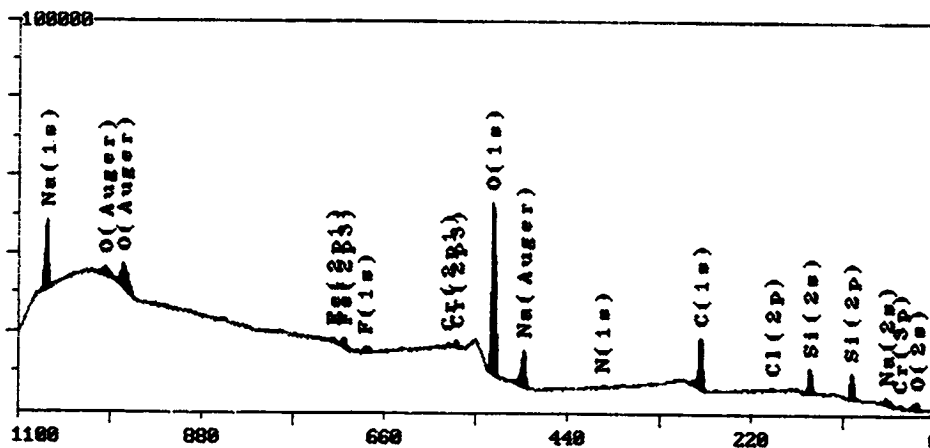
Surface Composition Table Summary

File name: D058C_01.MRS
 Region: 1
 Description: LDEF - Stainless Steel Bolt
 Operator: Jesse Cherian
 Date: Fri Sep 10 11:40 1993

Element	Binding Energy	atom %
Na (1s)	1069.5	9.07
Fe (2p3)	712.2	1.61
F (1s)	686.7	1.39
Cr (2p3)	577.2	0.57
O (1s)	531.8	38.38
N (1s)	399.2	1.10
C (1s)	284.6	35.35
Cl (2p)	197.9	0.44
Si (2p)	102.3	11.21
K (2p)	294.5	0.88

Figure A-25 Survey ESCA spectrum for stainless steel bolt D5, 8c-1.

Mon Sep 13 06:09:25 M-Probe ESCA Console User ID: JESSE
 D058C_02.MRS Fri Sep 10 12:46:34 1993 Operator: Jesse Cherian
 LDEF - Stainless Steel Bolt
 Spot: 400x1000µ Resolution: 4 Energy:
 Scans: 20 of 20 Neutralizer: 0.1eV Counts:
 Region: 1/ 1 Aperture: None



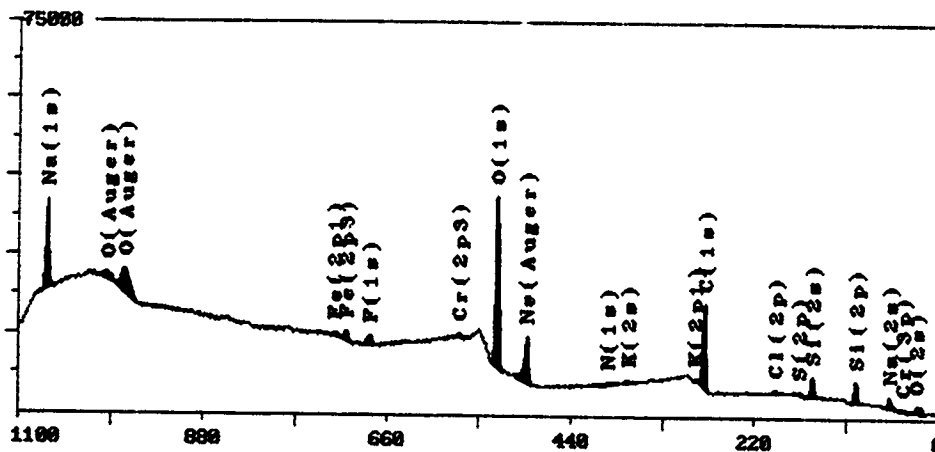
Surface Composition Table Summary

File name: D058C_02.MRS
 Region: 1
 Description: LDEF - Stainless Steel Bolt
 Operator: Jesse Cherian
 Date: Fri Sep 10 12:46 1993

Element	Binding Energy	atom %
Na (1s)	1070.0	9.84
Fe (2p3)	712.5	1.29
F (1s)	686.8	1.45
Cr (2p3)	577.5	0.48
O (1s)	532.0	40.01
N (1s)	400.5	0.68
C (1s)	284.6	35.35
Cl (2p)	197.9	0.32
Si (2p)	102.5	10.58

Figure A-26 Survey ESCA spectrum for stainless steel bolt D5, 8c-2.

Mon Sep 13 06:53:30 M-Probe ESCA Console User ID: JESSE
 B063B_01.MRS Fri Sep 10 18:09:59 1993 Operator: Jesse Cherian
 LDEF - Stainless Steel Bolt
 Spot: 400x1000µ Resolution: 4 Energy:
 Scans: 20 of 20 Neutralizer: 0.1eV Counts:
 Region: 1/ 1 Aperture: None



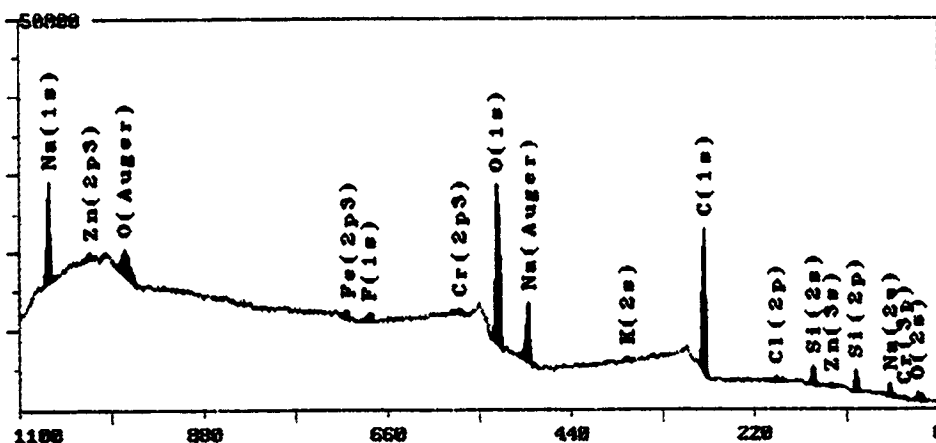
Surface Composition Table Summary

File name: B063B_01.MRS
 Region: 1
 Description: LDEF - Stainless Steel Bolt
 Operator: Jesse Cherian
 Date: Fri Sep 10 18:09 1993

Element	Binding Energy	atom %
Na (1s)	1071.2	10.90
Fe (2p3)	713.2	1.22
F (1s)	684.6	2.02
Cr (2p3)	578.3	0.40
O (1s)	532.8	36.02
N (1s)	401.1	0.98
C (1s)	284.6	39.42
Cl (2p)	198.1	0.41
S (2p)	170.0	0.73
Si (2p)	103.5	7.90

Figure A-27 Survey ESCA spectrum for stainless steel bolt B6, 3b-1.

Mon Sep 13 14:04:20 M-Probe ESCA Console User ID: JESSE
 B063B_02.MRS Mon Sep 13 13:22:04 1993 Operator: Jesse Cherian
 LDEF - Stainless Steel Bolt
 Spot: 400x1000µ Resolution: 4 Energy:
 Scans: 20 of 20 Neutralizer: 8.1eV Counts:
 Region: 1/ 1 Aperture: None



Surface Composition Table Summary

File name: B063B_02.MRS
 Region: 1
 Description: LDEF - Stainless Steel Bolt
 Operator: Jesse Cherian
 Date: Mon Sep 13 13:22 1993

Element	Binding Energy	atom %
Na (1s)	1071.2	9.55
Zn (2p3)	1021.9	0.66
Fe (2p3)	713.0	0.58
F (1s)	687.6	1.70
Cr (2p3)	579.0	0.32
O (1s)	533.3	30.67
C (1s)	284.6	49.25
Cl (2p)	198.3	0.93
Si (2p)	104.0	6.36

Figure A-28 Survey ESCA spectrum for stainless steel bolt B6, 3b-2.

Mon Sep 13 12:07:39

M-Probe ESCA Console

User ID: JESSIE

B068B_01.MRS

Fri Sep 10 20:19:20 1993

Operator: Jesse Cherian

LDEF - Stainless Steel Bolt

Spot: 100x1000µ

Resolution: 1

Energy: 960.73 eV

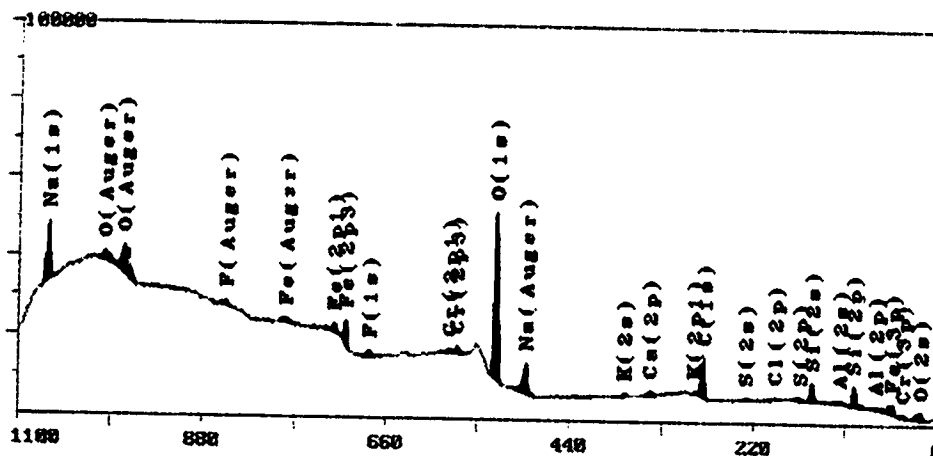
Scans: 20 of 20

Neutralizer: 0.1eV

Counts: 37540

Region: 1/ 1

Aperture: Mono



Surface Composition Table Summary

File name: B068B_01.MRS

Region: 1

Description: LDEF - Stainless Steel Bolt

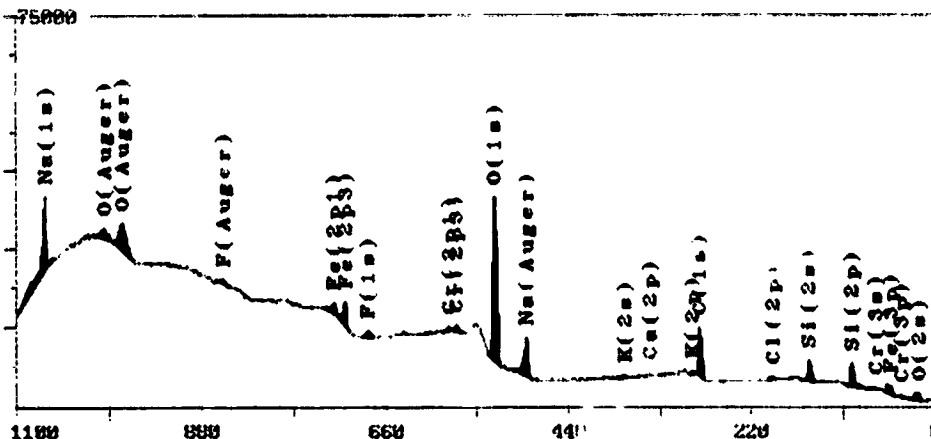
Operator: Jesse Cherian

Date: Fri Sep 10 20:19 1993

Element	Binding Energy	atom %
Na (1s)	1071.3	9.72
Fe (2p3)	713.7	1.82
F (1s)	685.8	1.36
Cr (2p3)	579.7	0.53
O (1s)	532.8	42.99
Ca (2p)	349.2	0.57
K (2p1)	295.6	0.39
C (1s)	284.6	25.17
S (2s)	234.1	0.78
Cl (2p)	198.7	0.33
S (2p)	168.7	0.47
Si (2p)	103.8	13.82
Al (2p)	77.6	2.04

Figure A-29 Survey ESCA spectrum for stainless steel bolt B6, 8b-1.

Mon Sep 13 09:37:19 M-Probe ESCA Console User ID: JESSE
 B068B_02.MRS Mon Sep 13 09:32:17 1993 Operator: Jesse Cherian
 LDEF - Stainless Steel Bolt
 Spot: 1000x1000p Resolution: 1 Energy:
 Scans: 20 of 20 Neutralizer: 0.1eV Counts:
 Region: 1/ 1 Aperture: None



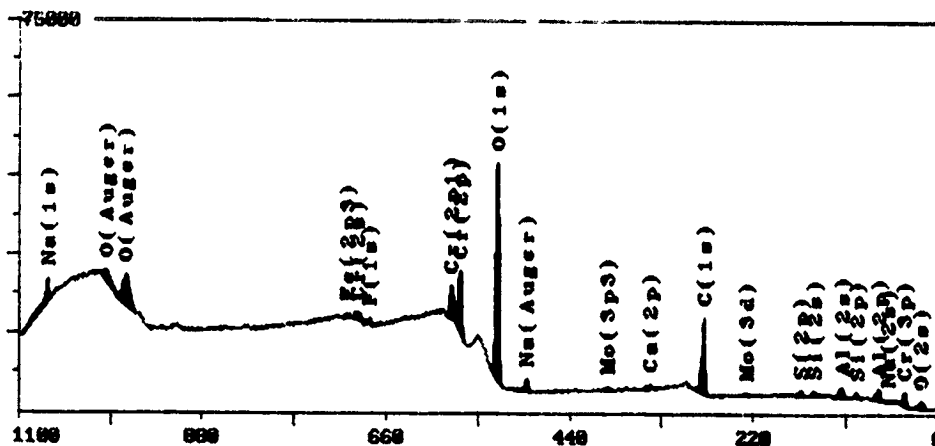
Surface Composition Table Summary

File name: B068B_02.MRS
 Region: 1
 Description: LDEF - Stainless Steel Bolt
 Operator: Jesse Cherian
 Date: Mon Sep 13 09:32 1993

Element	Binding Energy	atom %
Na (1s)	1068.8	10.12
Fe (2p3/2)	711.5	1.97
F (1s)	684.5	1.04
Cr (2p3/2)	577.4	0.50
O (1s)	530.7	40.31
K (2p)	293.3	0.18
C (1s)	284.0	25.25
Cl (2p)	196.0	0.57
Si (2p)	101.9	14.01

Figure A-30 Survey ESCA spectrum for stainless steel bolt B6, 8b-2.

Mon Sep 13 08:26:29 M-Probe ESCA Console User ID: JF55R
 B068B_03.MRS Mon Sep 13 08:00:16 1993 Operator: Jesse Cherian
 LDEF - Washer From Bolt B06-08
 Spot: 400x1000p Resolution: 4 Energy:
 Scans: 20 of 20 Neutralizer: 8.1eV Counts:
 Region: 1/ 1 Aperture: None



Surface Composition Table Summary

File name: B068B_03.MRS
 Region: 1
 Description: LDEF - Washer From Bolt B06-08
 Operator: Jesse Cherian
 Date: Mon Sep 13 08:00 1993

Element	Binding Energy	atom %
Na (1s)	1071.3	5.20
Fe (2p3)	712.3	0.51
F (1s)	684.9	1.11
O (1s)	531.4	44.38
C (1s)	284.6	35.01
Mo (3d)	232.4	0.13
S (2p)	168.8	1.08
Si (2p)	102.0	2.22
Al (2p)	74.8	10.36

Figure A-31 Survey ESCA spectrum for washer from stainless steel bolt B6, 8b-3.

Thu Aug 19 14:45:22 M-Probe ESCA Console User ID: JESSE
 F66C-1.MRS Tue Aug 17 10:41:41 1993 Operator: Jesse Chelian
 LDEF - Stainless Steel Bolt
 Spot: 400x1000µ Resolution: 4 Energy:
 Scans: 20 of 20 Neutralizer: 0.1eV Counts:
 Region: 1/ 1 Aperture: None

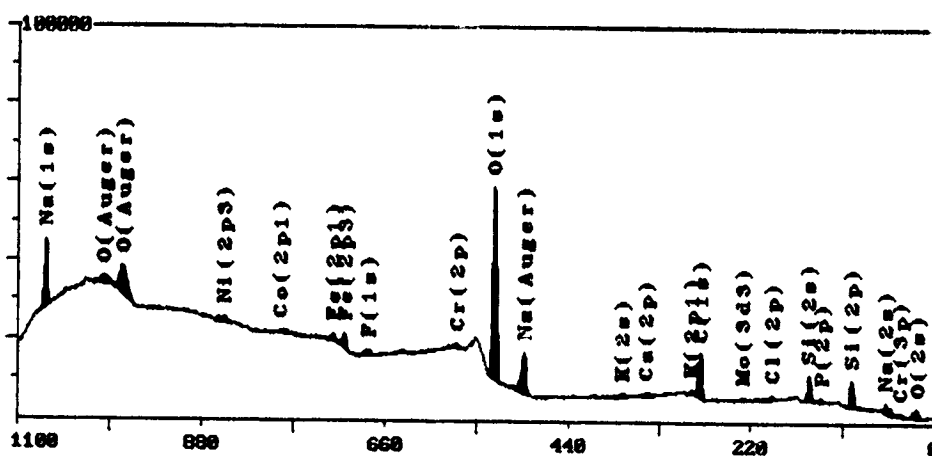


Figure A-32 Survey ESCA spectrum for stainless steel bolt F6, 6c-1.

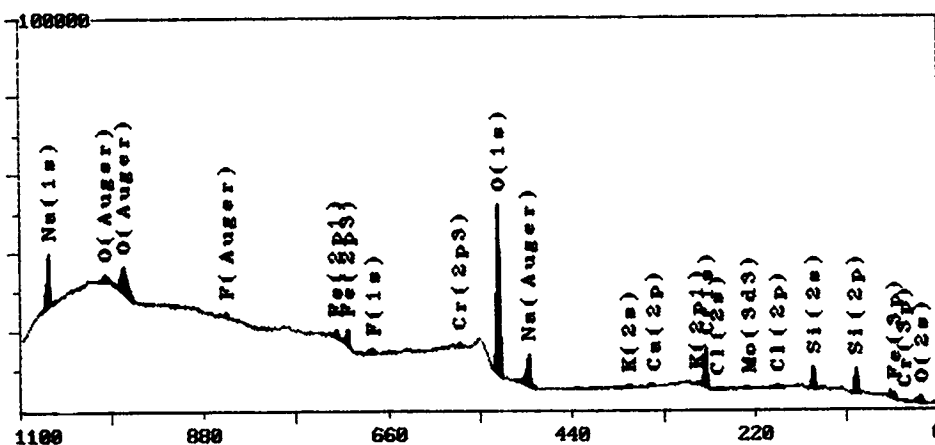
Surf. Composition Table Summary

File name: F66C_1.MRS
Region: 1
Description: LDEF - Stainless Steel Bolt
Operator: Jesse Cherian
Date: Tue Aug 17 10:41 1993

<u>Element</u>	<u>Binding Energy</u>	<u>atom %</u>
Na (1s)	1071.2	9.00
Ni (2p3)	858.1	0.53
Co (2p1)	790.2	1.43
Fe (2p3)	713.4	1.81
F (1s)	684.1	1.30
Cr (2p)	578.6	0.30
O (1s)	532.8	44.64
K (2s)	378.5	0.77
Ca (2p)	349.9	0.60
K (2p1)	295.1	0.89
C (1s)	284.6	22.05
Cl (2p)	198.3	0.49
P (2p)	140.5	1.14
Si (2p)	103.7	14.32
Mo (3d3)	234.0	0.73

Figure A-32 (Continued) Survey ESCA spectrum for stainless steel bolt F6, 6c-1.

Wed Aug 25 09:44:22 M-Probe ESCA Console User ID: JESSE
 F66C_2.MRS Tue Aug 17 11:57:10 1993 Operator: Jesse Cherian
 LDEF - Stainless Steel Bolt
 Spot: 400x1000µ Resolution: 4 Energy:
 Scans: 20 of 20 Neutralizer: 0.1eV Counts:
 Region: 1/ 1 Aperture: None



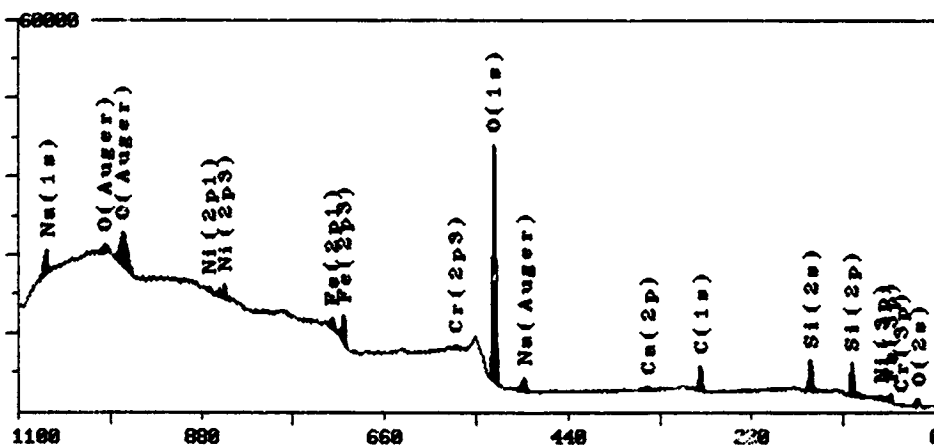
Surface Composition Table Summary

File name: F66C_2.MRS
 Region: 1
 Description: LDEF - Stainless Steel Bolt
 Operator: Jesse Cherian
 Date: Tue Aug 17 11:57 1993

Element	Binding Energy	atom %
Na (1s)	1071.1	9.65
Fe (2p3)	713.2	1.49
F (1s)	683.8	1.20
Cr (2p3)	579.4	0.36
O (1s)	532.7	47.73
Ca (2p)	348.3	0.32
K (2p1)	295.1	0.70
C (1s)	284.1	25.07
Mo (3d3)	233.1	0.20
Cl (2p)	198.0	0.87
Si (2p)	103.7	12.41

Figure A-33 Survey ESCA spectrum for stainless steel bolt F6, 6c-2.

Thu Aug 12 12:49:34 M-Probe ESCA Console User ID: JESSE
 F78A_1.MRS Thu Aug 12 10:03:19 1993 Operator: Jesse Cherian
 LDEF - Stainless Steel Bolt
 Spot: 400x1000µ Resolution: 4 Energy:
 Scans: 20 of 20 Neutralizer: 0.1eV Counts:
 Region: 1/ 1 Aperture: None



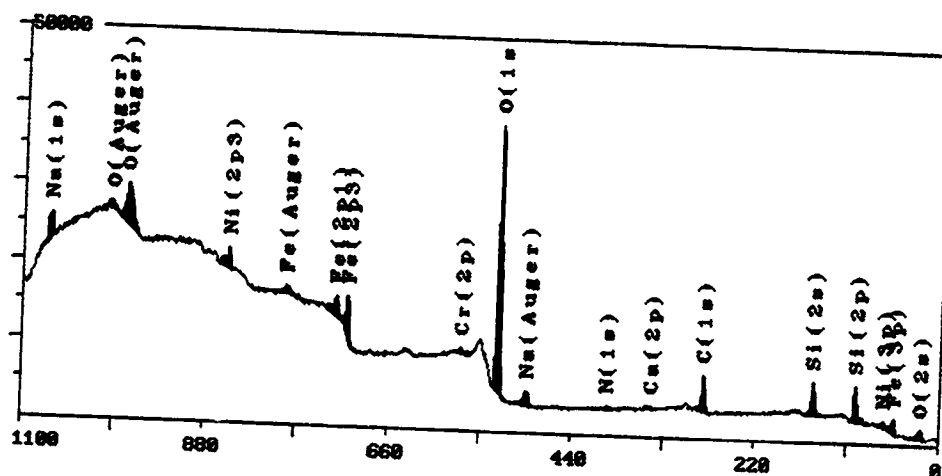
Surface Composition Table Summary

File name: F78A_1.MRS
 Region: 1
 Description: LDEF - Stainless Steel Bolt
 Operator: Jesse Cherian
 Date: Thu Aug 12 10:03 1993

Element	Binding Energy	atom %
Na (1s)	1069.8	5.10
Ni (2p3)	856.1	2.39
Fe (2p3)	712.0	2.07
Cr (2p3)	578.5	0.41
O (1s)	531.7	55.92
Ca (2p)	347.4	0.40
C (1s)	284.6	16.15
Si (2p)	102.3	17.56

Figure A-34 Survey ESCA spectrum for stainless steel bolt F7,8a-1.

Thu Aug 12 12:51:58 M-Probe ESCA Console User ID: JESSE
 F78A_2.MRS Thu Aug 12 11:09:15 1993 Operator: Jesse Cherian
 LDEF - Stainless Steel Bolt
 Spot: 400x1000µ Resolution: 4
 Scans: 20 of 20 Neutralizer: 0.1eV Energy:
 Region: 1/ 1 Aperture: None Counts:



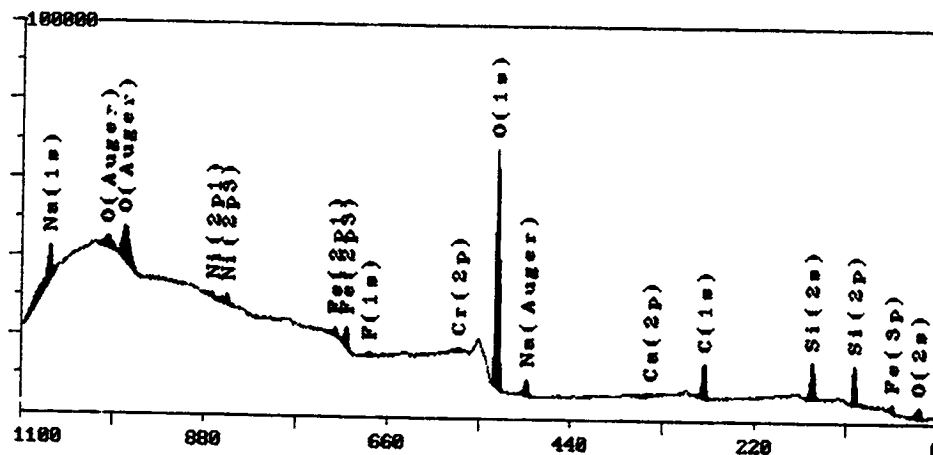
Surface Composition Table Summary

File name: F78A_2.MRS
 Region: 1
 Description: LDEF - Stainless Steel Bolt
 Operator: Jesse Cherian
 Date: Thu Aug 12 11:09 1993

Element	Binding Energy	atom %
Na (1s)	1069.6	5.11
Ni (2p3)	855.7	3.06
Fe (2p3)	711.7	2.77
Cr (2p)	576.7	0.40
O (1s)	531.0	52.87
N (1s)	400.3	0.46
Ca (2p)	347.2	0.31
C (1s)	284.6	16.67
Si (2p)	102.0	18.35

Figure A-35 Survey ESCA spectrum for stainless steel bolt F7, 8a-2.

Wed Aug 11 11:30:37 M-Probe ESCA Console User ID: JESSE
 E84B_1.MRS Tue Aug 10 20:04:46 1993 Operator: Jesse Cherian
 LDEF - Stainless Steel Bolt
 Spot: 400x1000p Resolution: 4 Energy:
 Scans: 20 of 20 Neutralizer: 0.1eV Counts:
 Region: 1/ 1 Aperture: None



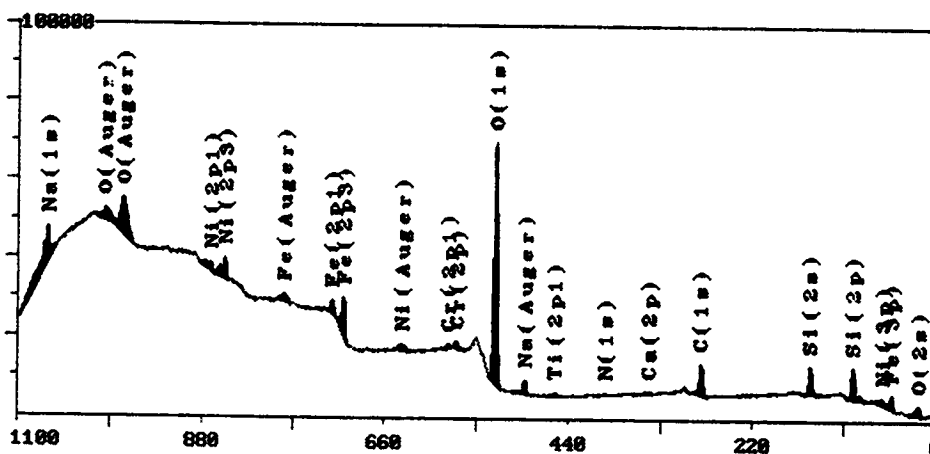
Surface Composition Table Summary

File name: E84B_1.MRS
 Region: 1
 Description: LDEF - Stainless Steel Bolt
 Operator: Jesse Cherian
 Date: Tue Aug 10 20:04 1993

Element	Binding Energy	atom %
Na (1s)	1071.0	10.83
Ni (2p3)	857.1	0.92
Fe (2p3)	712.8	1.61
F (1s)	686.5	0.55
Cr (2p)	578.4	0.24
O (1s)	533.0	49.47
Ca (2p)	348.6	0.46
C (1s)	284.6	18.50
Si (2p)	103.6	17.42

Figure A-36 Survey ESCA spectrum for stainless steel bolt E8, 4b-1.

Wed Aug 11 11:34:58 M-Probe ESCA Console User ID: JESSE
 E84B_2.MRS Tue Aug 10 21:09:26 1993 Operator: Jesse Cherian
 LDEF - Stainless Steel Bolt
 Spot: 488x1888y Resolution: 4 Energy:
 Scans: 20 of 20 Neutralizer: 0.1eV Counts:
 Region: 1/ 1 Aperture: None



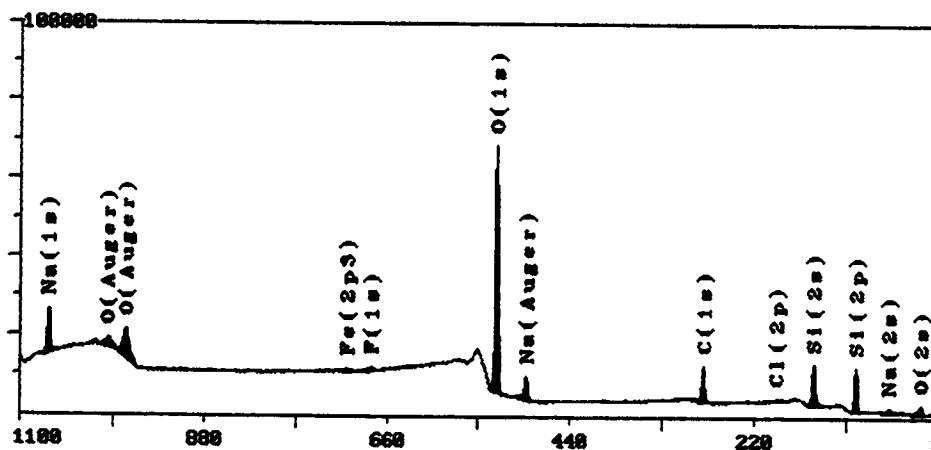
Surface Composition Table Summary

File name: E84B_2.MRS
 Region: 1
 Description: LDEF - Stainless Steel Bolt
 Operator: Jesse Cherian
 Date: Tue Aug 10 21:09 1993

Element	Binding Energy	atom %
Na (1s)	1069.2	13.57
Ni (2p3)	855.6	1.74
Fe (2p3)	711.7	2.65
Cr (2p)	576.9	0.33
O (1s)	530.7	47.10
N (1s)	399.2	0.40
C (1s)	284.6	16.61
Si (2p)	101.9	17.60

Figure A-37 Survey ESCA spectrum for stainless steel bolt E8, 4b-2.

Tue Aug 10 10:34:15 M-Probe ESCA Console User ID: JESSE
 F95A_1.MRS Tue Aug 10 10:17:06 1993 Operator: Jesse Cherian
 LDEF - Stainless Steel Bolt
 Spot: 400x1000µ Resolution: 4 Energy:
 Scans: 20 of 20 Neutralizer: 0.1eV Counts:
 Region: 1/ 1 Aperture: None



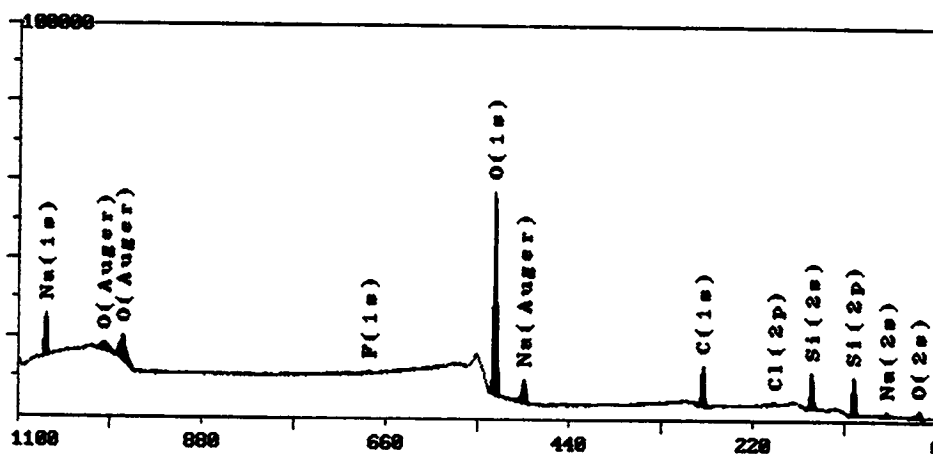
Surface Composition Table Summary

File name: F95A_1.MRS
 Region: 1
 Description: LDEF - Stainless Steel Bolt
 Operator: Jesse Cherian
 Date: Tue Aug 10 10:17 1993

Element	Binding Energy	atom %
Na (1s)	1071.6	6.91
Fe (2p3)	713.7	0.25
F (1s)	684.5	0.74
O (1s)	532.5	53.02
C (1s)	284.6	17.83
Cl (2p)	198.6	0.69
Si (2p)	102.9	20.55

Figure A-38 Survey ESCA spectrum for stainless steel bolt F9, 5a-1.

Tue Aug 10 11:42:59 M-Probe ESCA Console User ID: JESSE
 F95A_2.MRS Tue Aug 10 11:35:22 1993 Operator: Jesse Cherian
 LDEF - Stainless Steel Bolt
 Spot: 400x1000µ Resolution: 4 Energy:
 Scans: 20 of 20 Neutralizer: 0.1eV Counts:
 Region: 1/ 1 Aperture: None



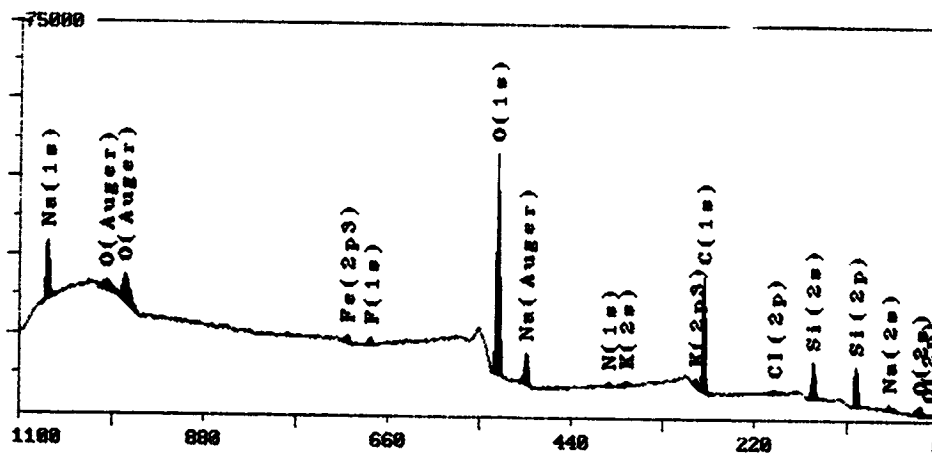
Surface Composition Table Summary

File name: F95A_2.MRS
 Region: 1
 Description: LDEF - Stainless Steel Bolt
 Operator: Jesse Cherian
 Date: Tue Aug 10 11:35 1993

Element	Binding Energy	atom %
Na (1s)	1071.6	7.42
F (1s)	684.2	0.58
O (1s)	532.4	49.91
C (1s)	284.6	22.17
Cl (2p)	198.6	0.40
Si (2p)	102.8	19.52

Figure A-39 Survey ESCA spectrum for stainless steel bolt F9, 5a-2.

Mon Sep 13 06:21:40 M-Probe ESCA Console User ID: JESSE
 E104A_01.MRS Fri Sep 10 16:00:39 1993 Operator: Jesse Cherian
 LDEF - Stainless Steel Bolt
 Spot: 400x1000p Resolution: 4 Energy:
 Scans: 20 of 20 Neutralizer: 0.1eV Counts:
 Region: 1/ 1 Aperture: None



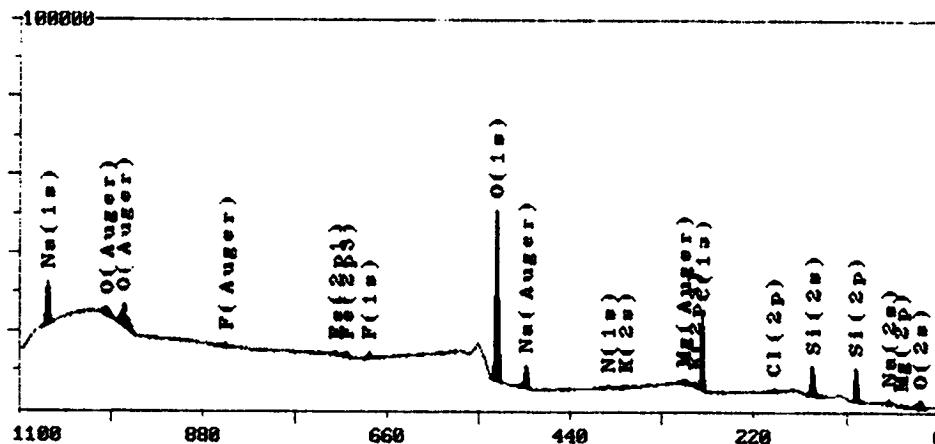
Surface Composition Table Summary

File name: E104A_01.MRS
 Region: 1
 Description: LDEF - Stainless Steel Bolt
 Operator: Jesse Cherian
 Date: Fri Sep 10 16:00 1993

Element	Binding Energy	atom %
Na (1s)	1071.4	7.01
Fe (2p3)	711.9	0.78
F (1s)	684.4	1.18
O (1s)	532.5	37.12
N (1s)	397.6	0.90
K (2p3)	293.3	0.74
C (1s)	284.6	38.48
Cl (2p)	199.0	0.53
Si (2p)	103.0	13.26

Figure A-40 Survey ESCA spectrum for stainless steel bolt E10,4a-1.

Mon Sep 13 06:26:55 M-Probe ESCA Console User ID: JESSE
 E104A_02.MRS Fri Sep 10 17:05:10 1993 Operator: Jesse Cherian
 LDEF - Stainless Steel Bolt
 Spot: 400x1000µ Resolution: 4 Energy:
 Scans: 20 of 20 Neutralizer: 0.1eV Counts:
 Region: 1/ 1 Aperture: None



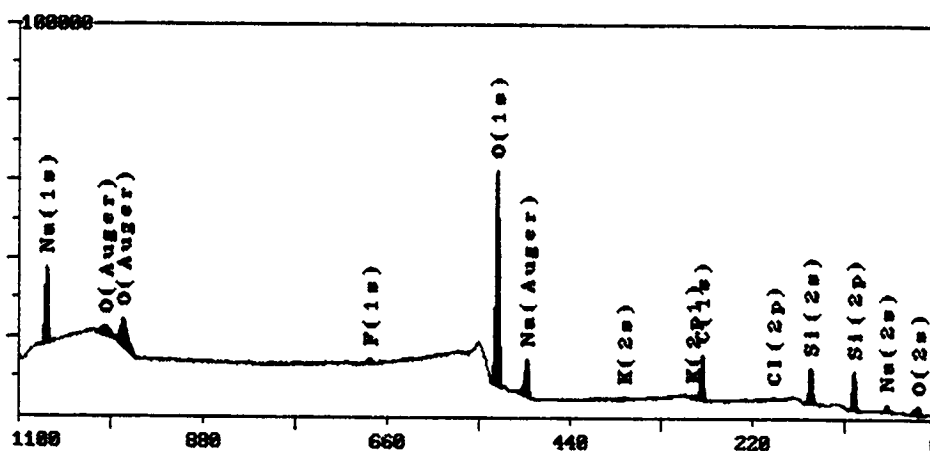
Surface Composition Table Summary

File name: E104A_02.MRS
 Region: 1
 Description: LDEF - Stainless Steel Bolt
 Operator: Jesse Cherian
 Date: Fri Sep 10 17:05 1993

Element	Binding Energy	atom %
Na (1s)	1071.3	6.52
Fe (2p3)	712.0	0.57
F (1s)	685.4	1.09
O (1s)	532.4	38.86
N (1s)	397.7	0.76
K (2p3)	293.7	0.65
C (1s)	284.6	34.92
Cl (2p)	198.8	0.50
Si (2p)	102.9	14.47
Mg (2p)	47.6	1.65

Figure A-41 Survey ESCA spectrum for stainless steel bolt E10, 4a-2.

Thu Aug 12 07:42:58 M-Probe ESCA Console User ID: JESSE
 E101C_1.MRS Wed Aug 11 00:23:27 1993 Operator: Jesse Cherian
 LDEF - Stainless Steel Bolt
 Spot: 400x1000µ Resolution: 4 Energy:
 Scans: 20 of 20 Neutralizer: 0.1eV Counts:
 Region: / 1 Aperture: None



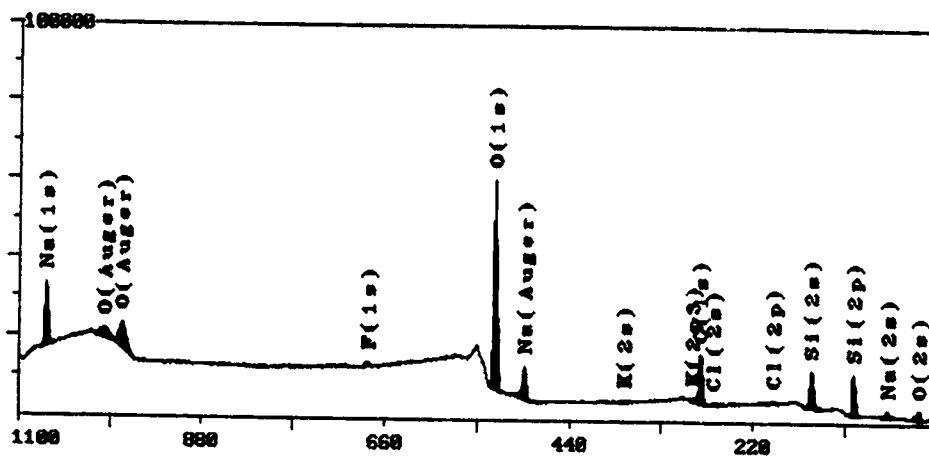
Surface Composition Table Summary

File name: E101C_1.MRS
 Region: 1
 Description: LDEF - Stainless Steel Bolt
 Operator: Jesse Cherian
 Date: Wed Aug 11 00:23 1993

Element	Binding Energy	atom %
Na (1s)	1071.6	10.80
F (1s)	684.2	1.06
O (1s)	532.4	47.37
K (2p1)	296.4	0.76
C (1s)	284.6	21.90
Si (2p)	102.9	18.10

Figure A-42 Survey ESCA spectrum for stainless steel bolt E10, 1c-1.

Thu Aug 12 08:04:08 M-Probe ESCA Console User ID: JESSE
 E101C_2.MRS Wed Aug 11 01:28:07 1993 Operator: Jesse Cherian
 LDEF - Stainless Steel Bolt
 Spot: 400x1000µ Resolution: 4 Energy:
 Scans: 28 of 28 Neutralizer: 0.1eV Counts:
 Region: 1/ 1 Aperture: None



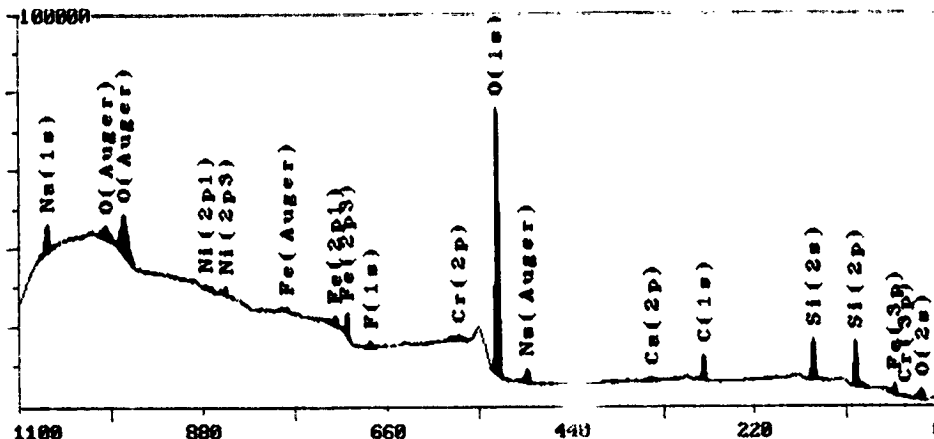
Surface Composition Table Summary

File name: E101C_2.MRS
 Region: 1
 Description: LDEF - Stainless Steel Bolt
 Operator: Jesse Cherian
 Date: Wed Aug 11 01:28 1993

Element	Binding Energy	atom %
Na (1s)	1071.5	9.51
F (1s)	684.0	1.02
O (1s)	532.5	47.05
K (2p3)	293.6	0.43
C (1s)	284.6	23.10
Cl (2p)	198.3	0.70
Si (2p)	102.9	18.19

Figure A-43 Survey ESCA spectrum for stainless steel bolt E10, 1c-2.

Mon Sep 13 06:00:42 M-Probe ESCA Console User ID: JESSE
 A118A_01.MRS Thu Sep 09 14:57:26 1993 Operator: Jesse Cherian
 LDEF - Stainless Steel Bolt
 Spot: 400x1000p Resolution: 4 Energy:
 Scans: 20 of 20 Neutralizer: 0.1eV Counts:
 Region: 1/ 1 Aperture: None



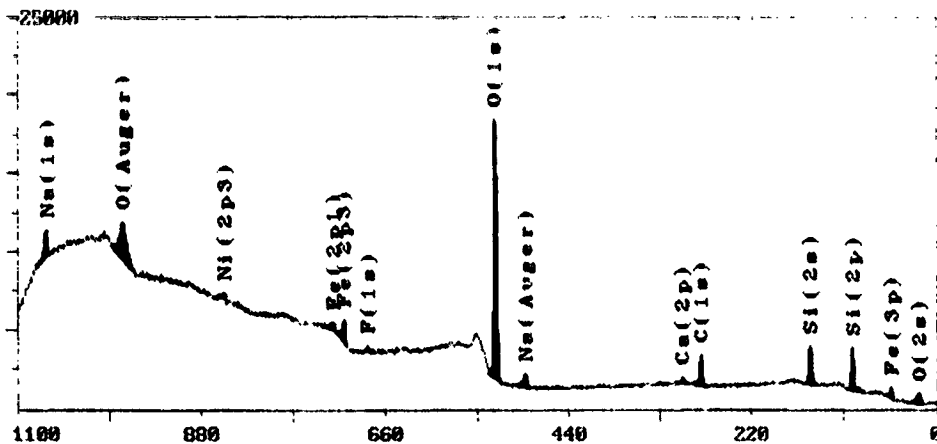
Surface Composition Table Summary

File name: A118A_01.MRS
 Region: 1
 Description: LDEF - Stainless Steel Bolt
 Operator: Jesse Cherian
 Date: Thu Sep 9 14:57 1993

Element	Binding Energy	atom %
Na (1s)	1070.9	5.61
Ni (2p3)	856.1	1.01
Fe (2p3)	712.2	1.55
F (1s)	684.3	1.07
Cr (2p)	578.1	0.92
O (1s)	531.9	55.74
Ca (2p)	347.9	0.40
C (1s)	284.6	13.30
Si (2p)	102.5	20.41

Figure A-44 Survey ESCA spectrum for stainless steel bolt A11, 8a-1.

Mon Sep 13 06:01:53 M-Probe ESCC Console User ID: JH...
 A1180_02.MRS Thu Sep 09 15:34:30 1993 Operator: Jesse Cherian
 LDEF - Stainless Steel Bolt
 Spot: 400x1000p Resolution: 4 Energy:
 Scans: 5 of 5 Neutralizer: 0.100 Counts:
 Region: 1/ 1 Aperture: None



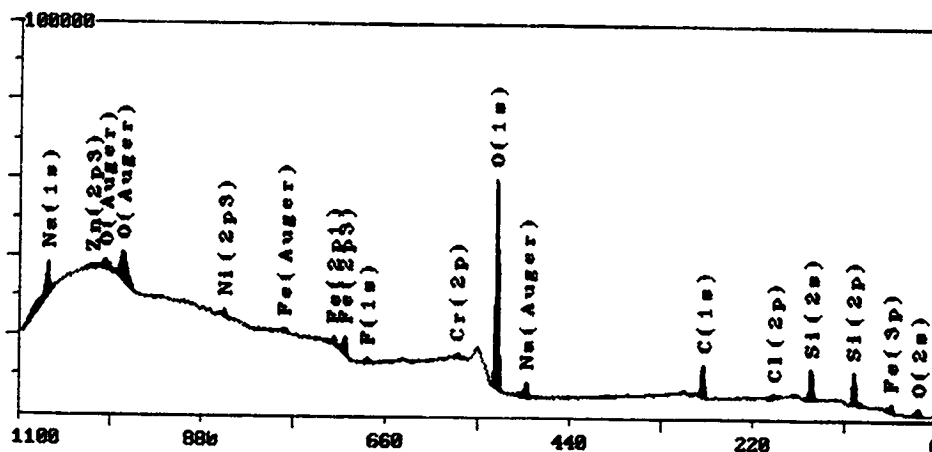
Surface Composition Table Summary

File name: A1180_02.MRS
 Region: 1
 Description: LDEF - Stainless Steel Bolt
 Operator: Jesse Cherian
 Date: Thu Sep 9 15:34 1993

Element	Binding Energy	atom %
Na (1s)	1070.6	5.02
Ni (2p3)	856.9	0.90
Fe (2p3)	712.6	2.81
F (1s)	685.1	0.84
O (1s)	532.1	51.66
Ca (2p)	307.1	0.63
C (1s)	284.6	15.44
Si (2p)	102.6	22.70

Figure A-45 Survey ESCA spectrum for stainless steel bolt A11, 8a-2.

Wed Aug 11 09:20:25 M-Probe ESCA Console User ID: JESSE
 B114C_1.MRS Tue Aug 10 15:46:04 1993 Operator: Jesse Cherian
 LDEF - Stainless Steel Bolt
 Spot: 400x1000µ Resolution: 4 Energy:
 Scans: 20 of 20 Neutralizer: 0.1eV Counts:
 Region: 1/ 1 Aperture: None



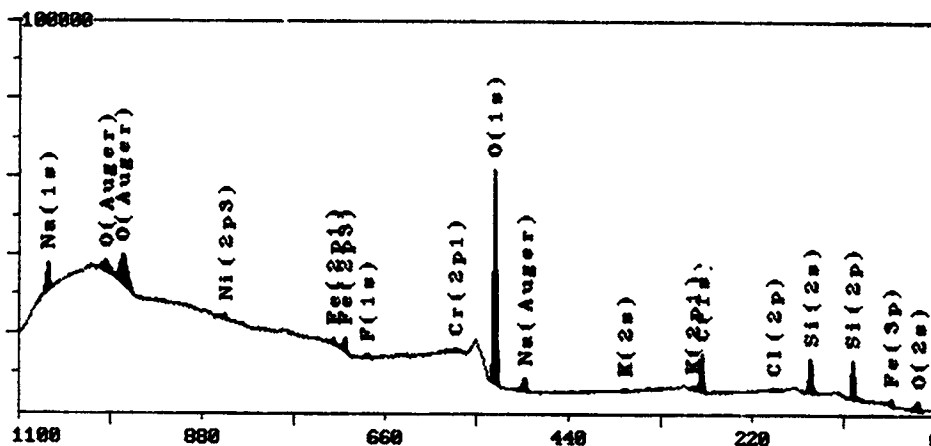
Surface Composition Table Summary

File name: B114C_1.MRS
 Region: 1
 Description: LDEF - Stainless Steel Bolt
 Operator: Jesse Cherian
 Date: Tue Aug 10 15:46 1993

Element	Binding Energy	atom %
Na (1s)	1071.0	12.03
zn (2p3)	1017.5	0.50
Ni (2p3)	857.5	0.82
Fe (2p3)	713.4	1.50
F (1s)	686.4	1.04
Cr (2p)	579.1	0.33
O (1s)	532.9	48.76
C (1s)	284.6	18.14
Si (2p)	103.5	16.88

Figure A-46 Survey ESCA spectrum for stainless steel bolt B11, 4c-1.

Wed Aug 11 09:22:21 M-Probe ESCA Console User ID: JESSE
 B114C_2.MRS Tue Aug 10 16:50:44 1993 Operator: Jesse Cherian
 LDEF - Stainless Steel Bolt
 Spot: 400x1000p Resolution: 4 Energy:
 Scans: 20 of 20 Neutralizer: 0.1eV Counts:
 Region: 1/ 1 Aperture: None



Surface Composition Table Summary

File name: B114C_2.MRS
 Region: 1
 Description: LDEF - Stainless Steel Bolt
 Operator: Jesse Cherian
 Date: Tue Aug 10 16:50 1993

Element	Binding Energy	atom %
Na (1s)	1071.0	9.62
Ni (2p3)	857.3	0.78
Fe (2p3)	712.6	1.14
F (1s)	686.4	0.94
Cr (2p1)	579.6	0.83
O (1s)	532.9	48.70
K (2p1)	294.9	1.01
C (1s)	284.6	19.06
Cl (2p)	198.2	0.39
Si (2p)	103.4	17.54

Figure A-47 Survey ESCA spectrum for stainless steel bolt B11, 4c-2.

Wed Aug 11 10:37:46

M-Probe ESCA Console

User ID: JESSE

D113B_1.MRS

Tue Aug 10 17:55:25 1993

Operator: Jesse Cherian

LDEF - Stainless Steel Bolt

Spot: 400x1000µ

Resolution: 4

Energy:

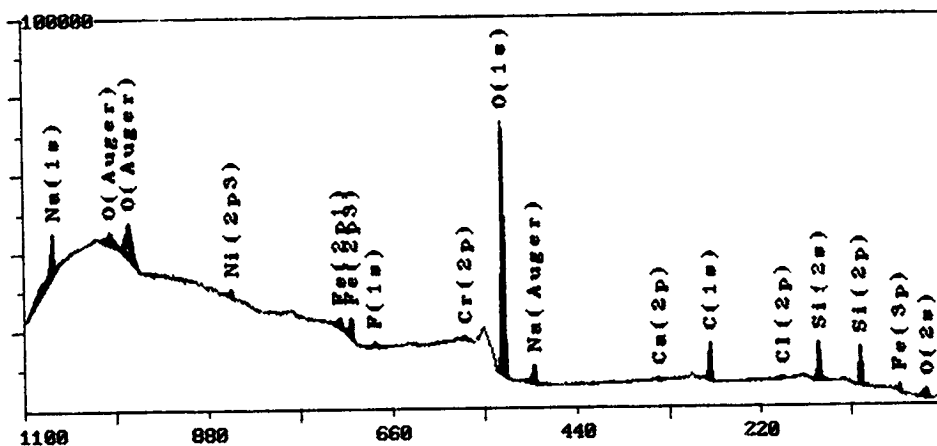
Scans: 20 of 20

Neutralizer: 0.1eV

Counts:

Region: 1/ 1

Aperture: None



Surface Composition Table Summary

File name: D113B_1.MRS

Region: 1

Description: LDEF - Stainless Steel Bolt

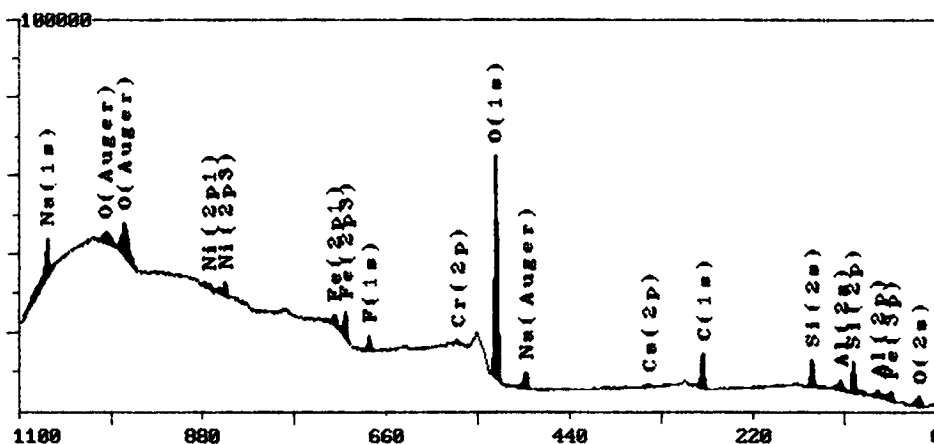
Operator: Jesse Cherian

Date: Tue Aug 10 17:55 1993

Element	Binding Energy	atom %
Na (1s)	1071.1	12.93
Ni (2p3)	857.5	0.44
Fe (2p3)	713.4	1.63
F (1s)	686.3	1.03
Cr (2p)	578.0	0.26
O (1s)	532.8	49.41
Ca (2p)	347.4	0.18
C (1s)	284.6	17.74
Cl (2p)	198.8	0.45
Si (2p)	103.4	15.93

Figure A-48 Survey ESCA spectrum for stainless steel bolt D11, 3b-1.

Wed Aug 11 11:27:19 M-Probe ESCA Console User ID: JESSE
D113B_2.MRS Tue Aug 10 19:00:05 1993 Operator: Jesse Cherian
LDEF - Stainless Steel Bolt
Spot: 400x1000µ Resolution: 4 Energy:
Scans: 20 of 20 Neutralizer: 0.1eV Counts:
Region: 1/ 1 Aperture: None



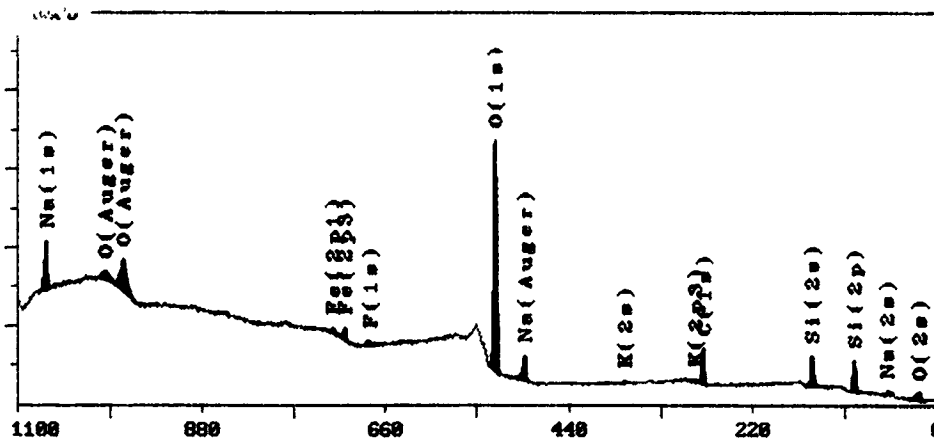
Surface Composition Table Summary

File name: D113B_2.MRS
Region: 1
Description: LDEF - Stainless Steel Bolt
Operator: Jesse Cherian
Date: Tue Aug 10 19:00 1993

Element	Binding Energy	atom %
Na (1s)	1071.3	10.67
Ni (2p3)	857.6	1.11
Fe (2p3)	713.5	2.89
F (1s)	685.3	2.16
O (1s)	532.7	44.18
Ca (2p)	349.1	0.30
C (1s)	284.6	17.20
Si (2p)	103.7	16.22
Al (2p)	73.9	5.28

Figure A-49 Survey ESCA spectrum for stainless steel bolt D11, 3b-2.

Thu Aug 07:17:19 M-Probe ESCA Console User ID: JESSE
 A128C_1. Thu Aug 12 07:42:17 1993 Operator: Jesse Cherian
 LDEF - Stainless Steel Bolt
 Spot: 300p Resolution: 4 Energy:
 Scans: 20 Neutralizer: 0.1eV Counts:
 Reg: 1 Aperture: None



Surface Composition Table Summary

File name: A128C_1.MRS
 Region: 1
 Description: LDEF - Stainless Steel Bolt
 Operator: Jesse Cherian
 Date: Thu Aug 12 07:42 1993

Element	Binding Energy	atom %
Na (1s)	1071.4	7.88
Fe (2p3)	713.5	1.47
F (1s)	683.8	1.19
O (1s)	532.7	54.83
K (2p3)	294.5	0.74
C (1s)	284.6	17.92
Si (2p)	103.3	15.97

Figure A-50 Survey ESCA spectrum for stainless steel bolt A12, 8c-1.

Thu Aug 12 09:21:2

M-Probe ESCA Console

User ID: JESSE

A128C_2.MRS

Thu Aug 12 08:51:58 1993

Operator: Jesse Cherian

LDEF - Stainless Steel Bolt

Spot: 400x1000u

Resolution: 4

Energy:

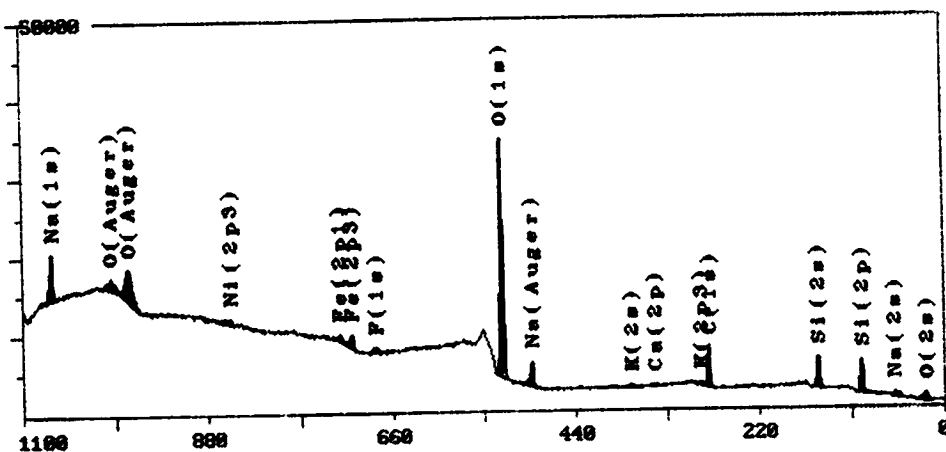
Scans: 20 of 20

Neutralizer: 0.1eV

Counts:

Region: 1/ 1

Aperture: None



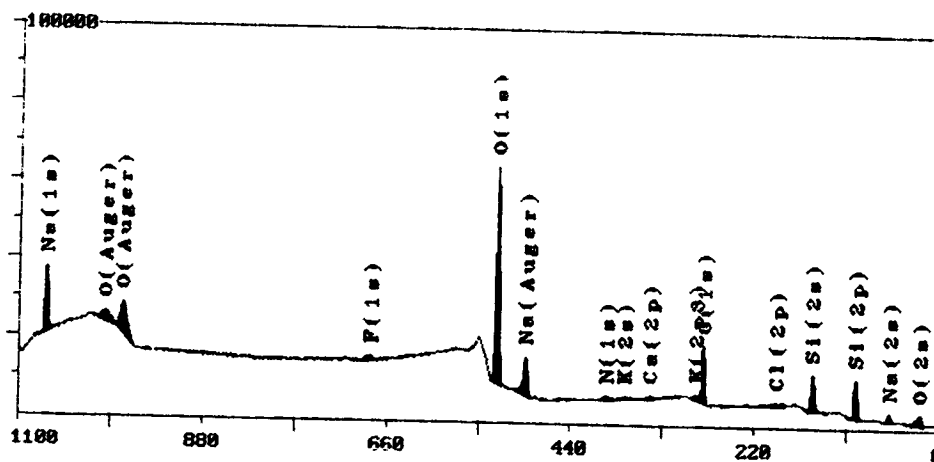
Surface Composition Table Summary

File name: A128C_2.MRS
Region: 1
Description: LDEF - Stainless Steel Bolt
Operator: Jesse Cherian
Date: Thu Aug 12 08:51 1993

Element	Binding Energy	atom %
Na (1s)	1071.4	7.22
Ni (2p3)	857.4	0.93
Fe (2p3)	713.4	1.72
F (1s)	686.0	1.20
O (1s)	532.7	54.08
Ca (2p)	348.7	0.30
K (2p3)	294.6	0.62
C (1s)	284.6	17.96
Si (2p)	103.3	15.96

Figure A-51 Survey ESCA spectrum for stainless steel bolt A12, 8c-2.

Thu Aug 12 07:46:41 M-Probe ESCA Console User ID: JESSE
 G612B_1.MRS Tue Aug 10 22:14:06 1993 Operator: Jesse Cherian
 LDEF - Stainless Steel Bolt
 Spot: 400x1000p Resolution: 4 Energy:
 Scans: 20 of 20 Neutralizer: 0.1eV Counts:
 Region: 1/ 1 Aperture: None



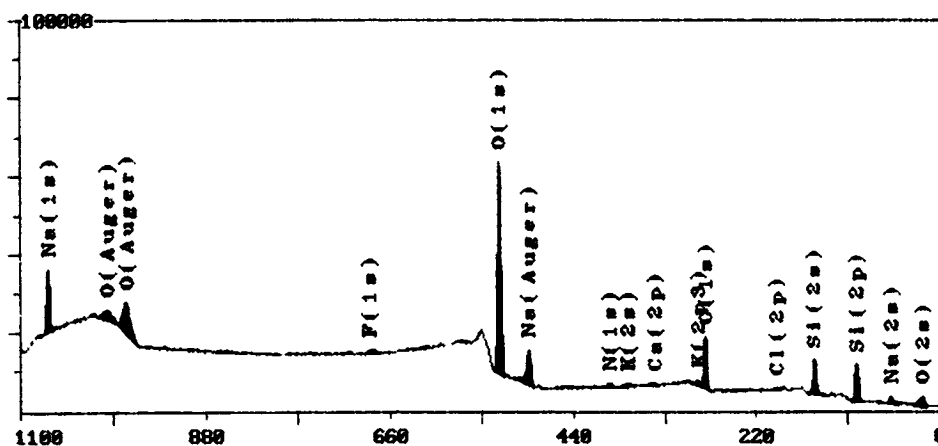
Surface Composition Table Summary

File name: G612B_1.MRS
 Region: 1
 Description: LDEF - Stainless Steel Bolt
 Operator: Jesse Cherian
 Date: Tue Aug 10 22:14 1993

Element	Binding Energy	atom %
Na (1s)	1071.6	7.83
F (1s)	684.5	1.08
O (1s)	532.3	38.04
N (1s)	399.0	0.78
Ca (2p)	347.6	0.17
K (2p3)	293.5	0.55
Cl (1s)	284.6	20.50
Cl (2p)	197.9	0.76
Si (2s)	153.6	16.51
Si (2p)	102.7	13.78

Figure A-52 Survey ESCA spectrum for stainless steel bolt G6, 12b-1.

Thu Aug 12 07:50:09 M-Probe ESCA Console User ID: JESSE
 G612B_2.MRS Tue Aug 10 23:18:46 1993 Operator: Jesse Cherian
 LDEF - Stainless Steel Bolt
 Spot: 400x1000p Resolution: 4 Energy:
 Scans: 20 of 20 Neutralizer: 0.1eV Counts:
 Region: 1/ 1 Aperture: None



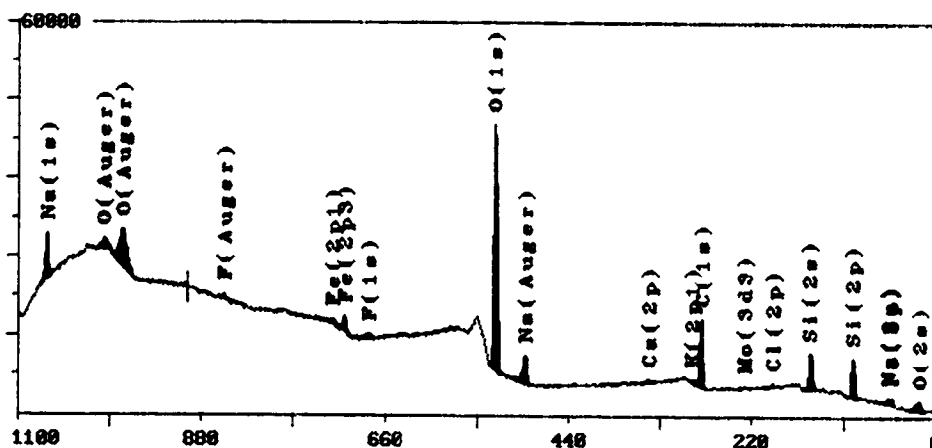
Surface Composition Table Summary

File name: G612B_2.MRS
 Region: 1
 Description: LDEF - Stainless Steel Bolt
 Operator: Jesse Cherian
 Date: Tue Aug 10 23:18 1993

Element	Binding Energy	atom %
Na (1s)	1071.6	8.79
F (1s)	688.5	1.07
O (1s)	532.3	46.08
N (1s)	399.7	1.09
Ca (2p)	346.6	0.23
K (2p3)	294.0	0.81
C (1s)	284.6	25.01
Cl (2p)	198.8	0.36
Si (2p)	102.9	16.55

Figure A-53 Survey ESCA spectrum for stainless steel bolt G6, 12b-2.

Thu Aug 19 14:46:03 M-Probe ESCA Console User ID: JESSE
 H65C_1.MRS Tue Aug 17 14:00:19 1993 Operator: Jesse Cherian
 LDEF - Stainless Steel Bolt
 Spot: 400x1000µ Resolution: 4 Energy: 897.60 eV
 Scans: 20 of 20 Neutralizer: 0.1eV Counts: 19135
 Region: 1/ 1 Aperture: None



Surface Composition Table Summary

File name: H65C_1.MRS
 Region: 1
 Description: LDEF - Stainless Steel Bolt
 Operator: Jesse Cherian
 Date: Tue Aug 17 14:00 1993

Element	Binding Energy	atom %
Na (1s)	1071.3	5.79
Fe (2p3)	713.8	1.71
F (1s)	684.2	0.97
O (1s)	533.6	50.04
Ca (2p)	348.3	0.40
K (2p1)	296.2	0.75
C (1s)	284.6	28.04
Mo (3d3)	232.4	0.18
Si (2p)	103.9	12.13

Figure A-54 Survey ESCA spectrum for stainless steel bolt H6, 5c-1.

Wed Aug 18 08:16:11

M-Probe ESCA Console

User ID: JESSE

H65C_2.MRS

Tue Aug 17 16:01:23 1993

Operator: Jesse Cherian

LDEF - Stainless Steel Bolt

Spot: 400x1000µ

Resolution: 4

Energy:

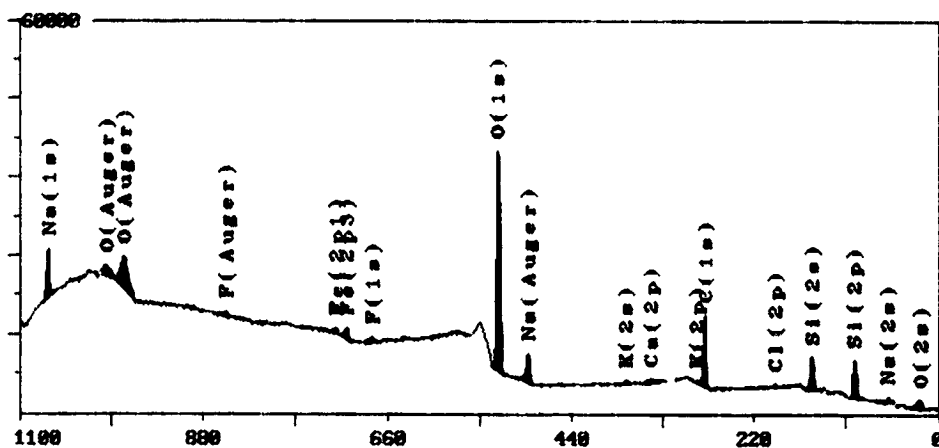
Scans: 20 of 20

Neutralizer: 0.1eV

Counts:

Region: 1/ 1

Aperture: None



Surface Composition Table Summary

File name: H65C_2.MRS

Region: 1

Description: LDEF - Stainless Steel Bolt

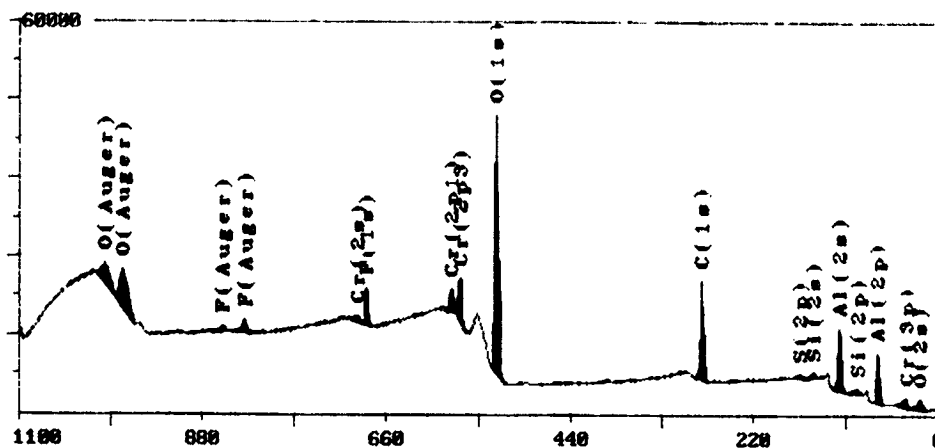
Operator: Jesse Cherian

Date: Tue Aug 17 16:01 1993

Element	Binding Energy	atom %
Na (1s)	1071.3	6.14
Fe (2p3)	713.1	1.12
F (1s)	683.7	1.05
O (1s)	533.2	46.76
Ca (2p)	348.7	0.41
C (1s)	284.6	28.27
Cl (2p)	198.4	0.51
Si (2p)	103.9	14.80
K (2p)	295.3	0.94

Figure A-55 Survey ESCA spectrum for stainless steel bolt H6, 5c-2.

Mod Aug 25 10:50:02 M-Probe ESCA Console User ID: JESSIE
 WASHIER.MRS Wed Aug 18 08:08:14 1993 Operator: Jesse Cherian
 LDEF - Stainless Steel Bolt
 Spot: 400x1000p Resolution: 4 Energy:
 Scans: 20 of 20 Neutralizer: 0.1eV Counts:
 Region: 1/ 1 Aperture: None



Surface Composition Table Summary

File name: WASHIER.MRS
 Region: 1
 Description: LDEF - Stainless Steel Bolt
 Operator: Jesse Cherian
 Date: Wed Aug 18 08:08 1993

Element	Binding Energy	atom %
F (1s)	686.0	3.72
Cr (2p3)	574.2	2.52
O (1s)	531.7	40.21
C (1s)	284.6	30.43
S (2p)	165.9	0.59
Si (2p)	98.0	1.25
Al (2p)	74.7	21.18

Figure A-56 Survey ESCA spectrum for washer from stainless steel bolt H6.

Sat Oct 16 05:22:54

M Probe ESCA Console

User ID: JESSE

CNTRL2_3.MRS

Sat Oct 16 05:14:55 1993

Operator: Jesse Cherian

LDEF Stainless Steel Bolt, Bottom Tip

Spot: 400x1000µ

Resolution: 3

Energy:

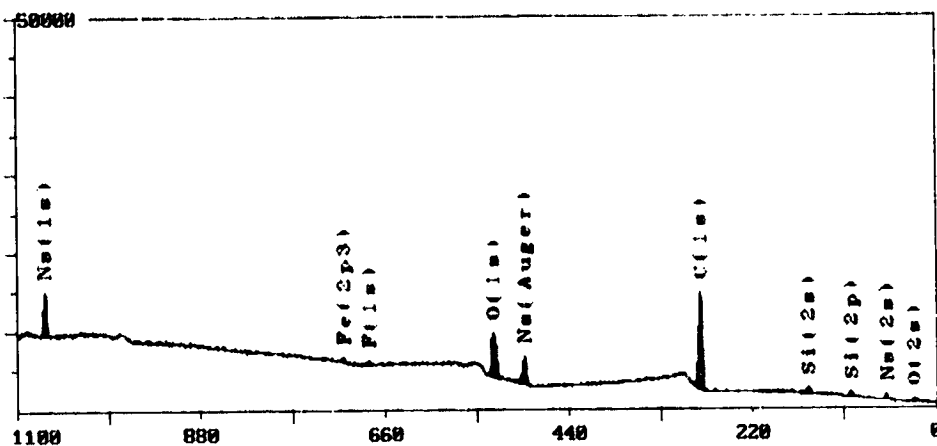
Scans: 20 of 20

Neutralizer: 0.1eV

Counts:

Region: 1/ 1

Aperture: None



Surface Composition Table Summary

File name: CNTRL2_3.MRS

Region: 1

Description: LDEF - Stainless Steel Bolt, Bottom Tip

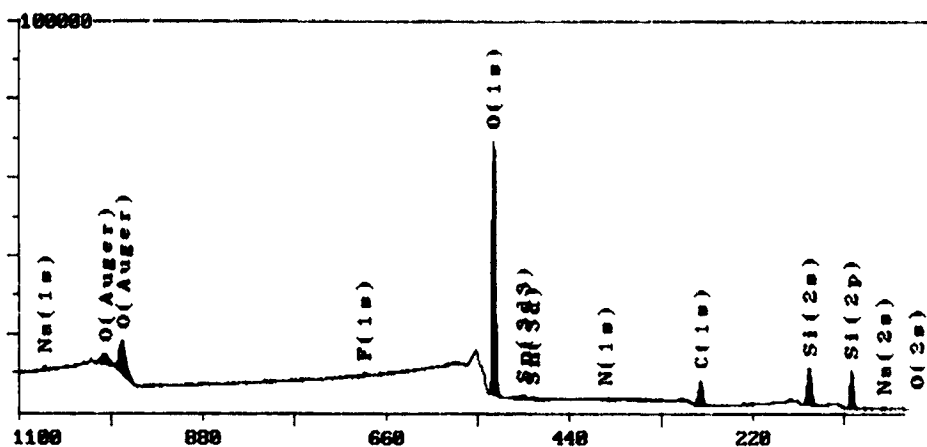
Operator: Jesse Cherian

Date: Sat Oct 16 05:14 1993

Element	Binding Energy	atom %
Na (1s)	1071.4	5.72
Fe (2p3)	714.1	0.41
F (1s)	683.8	0.60
O (1s)	533.9	19.00
C (1s)	284.6	70.64
Si (2p)	104.7	3.62

Figure A-57 Survey ESCA spectrum for bottom tip of ground control stainless steel bolt 2.

Fri Oct 15 10:57:59 M-Probe ESCA Console User ID: JESSF
 C038A_03.MRS Fri Oct 15 07:57:08 1993 Operator: Jesse Cherian
 LDEF - Stainless Steel Bolt, Bottom Tip
 Spot: 400x1000µ Resolution: 3 Energy:
 Scans: 20 of 20 Neutralizer: 0.1eV Counts:
 Region: 1/ 1 Aperture: None



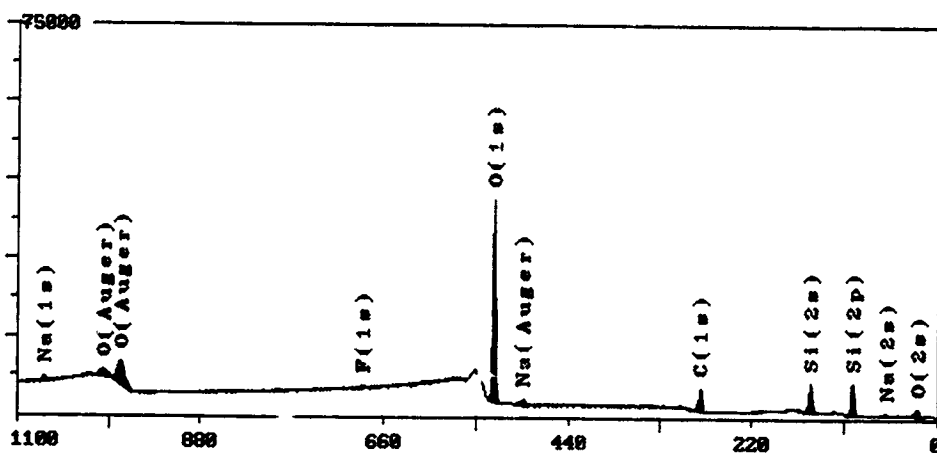
Surface Composition Table Summary

File name: C038A_03.MRS
 Region: 1
 Description: LDEF - Stainless Steel Bolt, Bottom Tip
 Operator: Jesse Cherian
 Date: Fri Oct 15 07:57 1993

Element	Binding Energy	atom %
Na (1s)	1072.0	0.58
F (1s)	688.4	0.37
O (1s)	532.0	58.65
Sn (3d)	486.3	0.03
N (1s)	400.0	0.34
C (1s)	284.6	16.96
Si (2p)	102.6	23.06

Figure A-58 Survey ESCA spectrum for bottom tip of stainless steel bolt C3, 8a.

Fri Oct 15 06:54:15 M-Probe ESCA Console User ID: JESSE
 D024C_03.MRS Fri Oct 15 06:43:29 1993 Operator: Jesse Cherian
 LDEF - Stainless Steel Bolt, Bottom Tip
 Spot: 480x1000µ Resolution: 3 Energy:
 Scans: 20 of 20 Neutralizer: 0.1eV Counts:
 Region: 1/ 1 Aperture: None



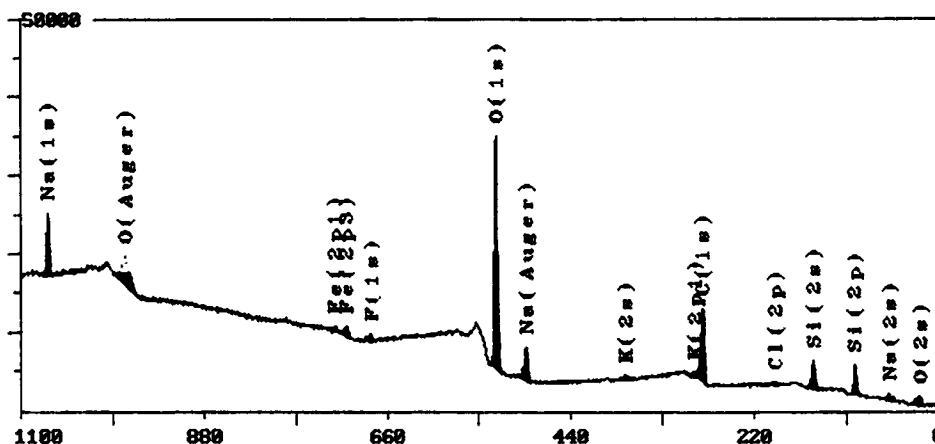
Surface Composition Table Summary

File name: D024C_03.MRS
 Region: 1
 Description: LDEF - Stainless Steel Bolt, Bottom Tip
 Operator: Jesse Cherian
 Date: Fri Oct 15 06:43 1993

Element	Binding Energy	atom %
Na (1s)	1072.1	0.81
F (1s)	687.7	0.72
O (1s)	532.3	56.68
C (1s)	284.6	20.12
Si (2p)	102.7	21.66

Figure A-59 Survey ESCA spectrum for bottom tip of stainless steel bolt D2, 4c.

Fri Oct 15 12:32:04 M-Probe ESCA Console User ID: JESSE
 E047C_03.MRS Fri Oct 15 11:59:09 1993 Operator: Jesse Cherian
 LDEF - Stainless Steel Bolt, Bottom Tip
 Spot: 400x1000µ Resolution: 3 Energy:
 Scans: 20 of 20 Neutralizer: 0.1eV Counts:
 Region: 1/ 1 Aperture: None



Surface Composition Table Summary

File name: E047C_03.MRS
 Region: 1
 Description: LDEF - Stainless Steel Bolt, Bottom Tip
 Operator: Jesse Cherian
 Date: Fri Oct 15 11:59 1993

Element	Binding Energy	atom %
Na (1s)	1071.1	5.62
Fe (2p3)	712.7	0.94
F (1s)	683.5	1.20
O (1s)	532.6	44.44
K (2p1)	294.5	1.15
C (1s)	284.6	33.34
Cl (2p)	198.8	0.49
Si (2p)	103.0	12.81

Figure A-60 Survey ESCA spectrum for bottom tip of stainless steel bolt E4, 7c.

Appendix B

Auger spectra from selected aluminum tray clamp surfaces and aluminum sheetstock.

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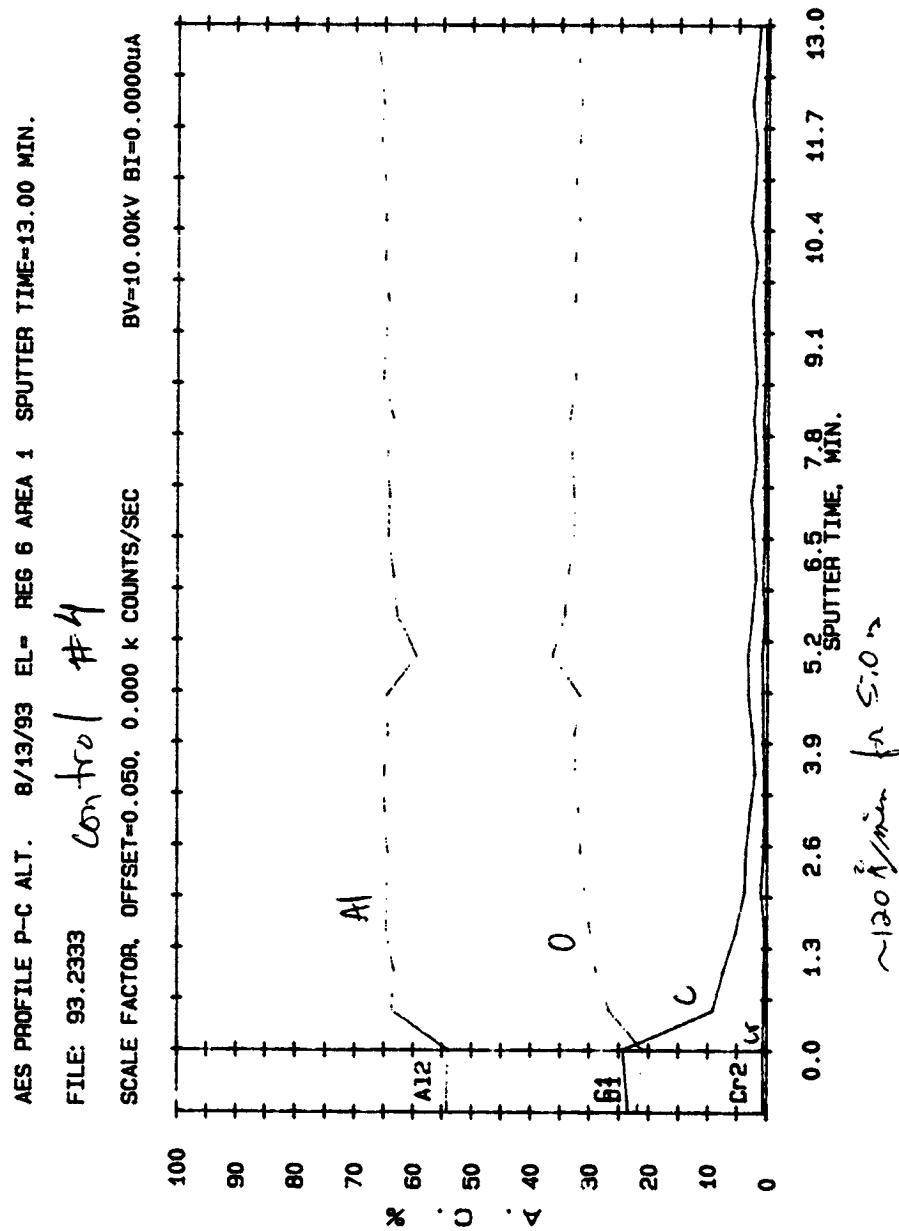


Figure B-1 Auger spectrum for control tray clamp 4.

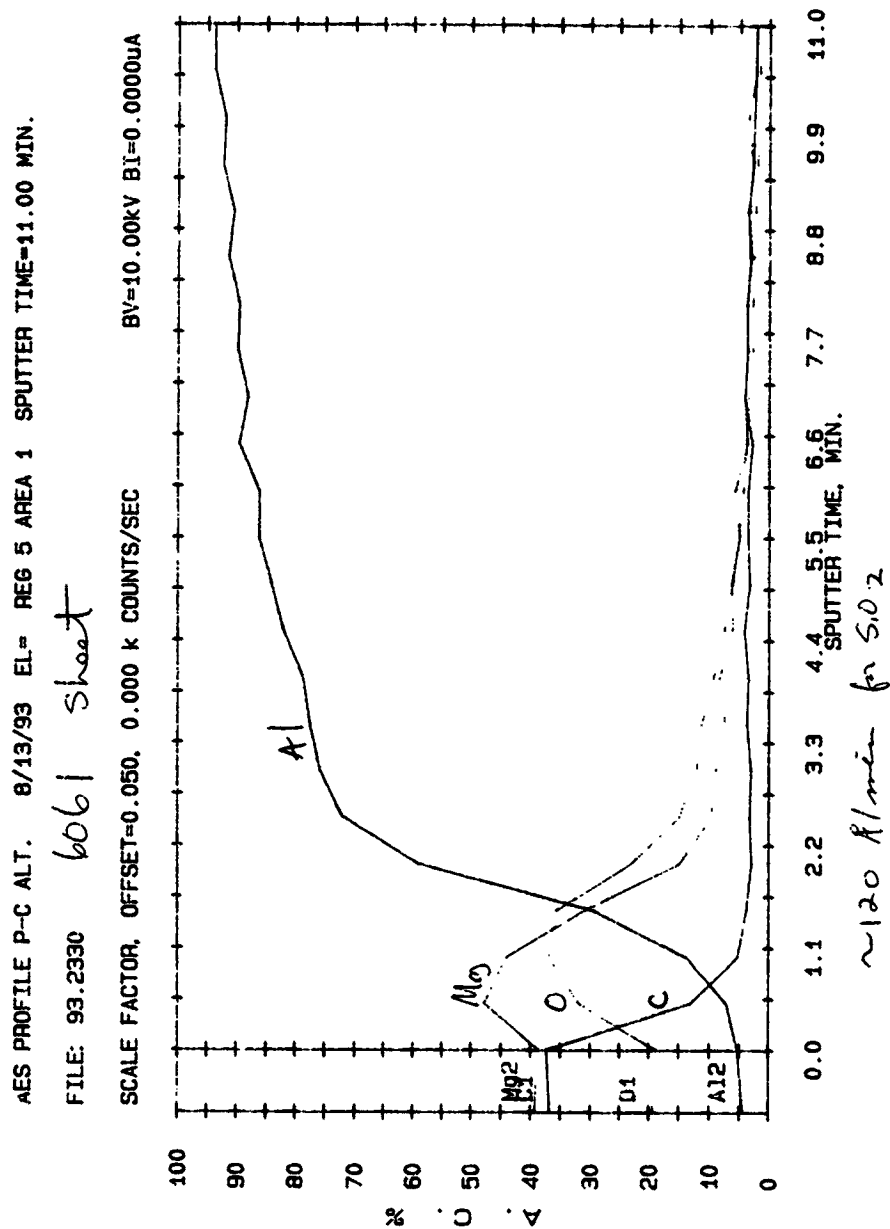


Figure B-2 Auger spectrum for T-6061 aluminum sheetstock.

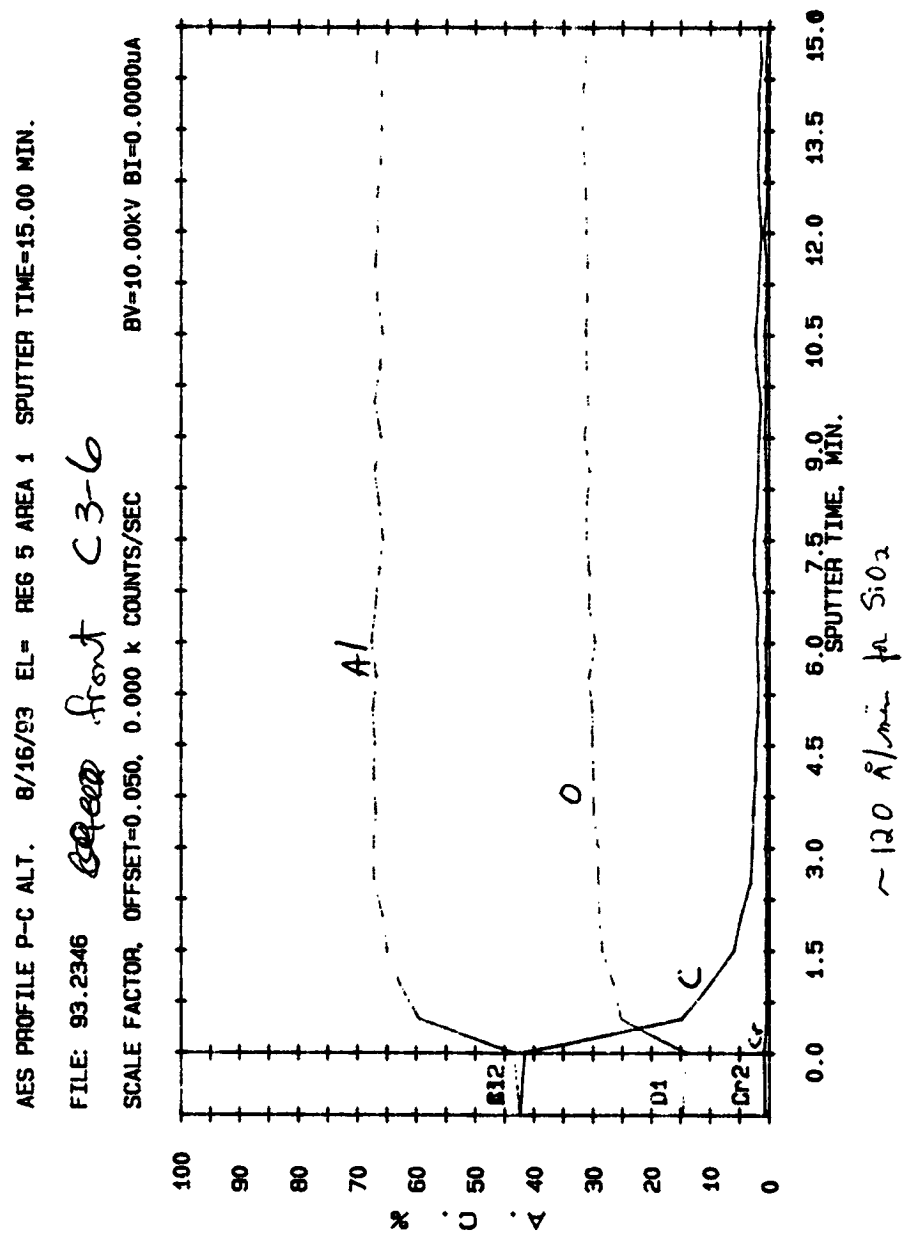


Figure B-3 Auger spectrum for front surface of tray clamp C3-6.

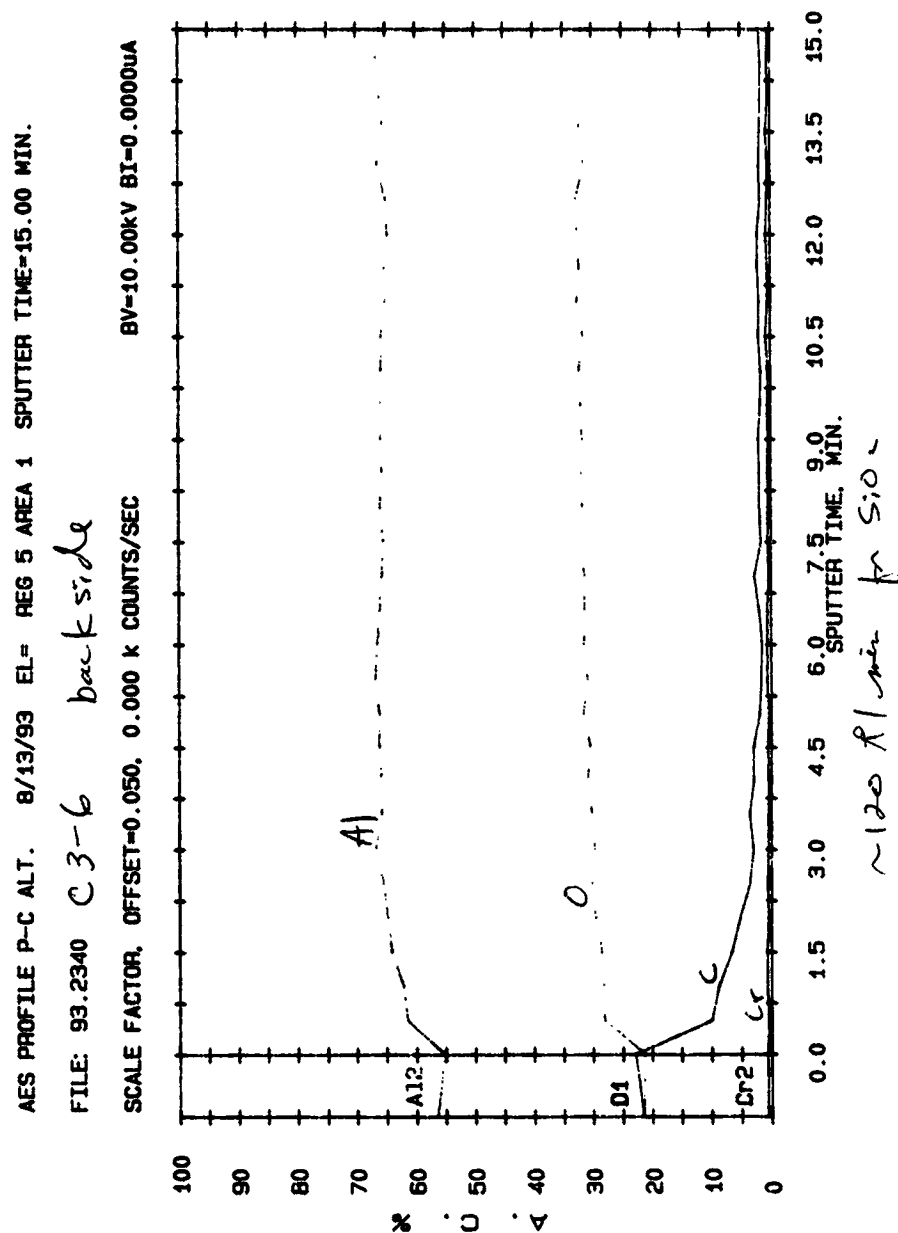


Figure B-4 Auger spectrum for back surface of tray clamp C3-6.

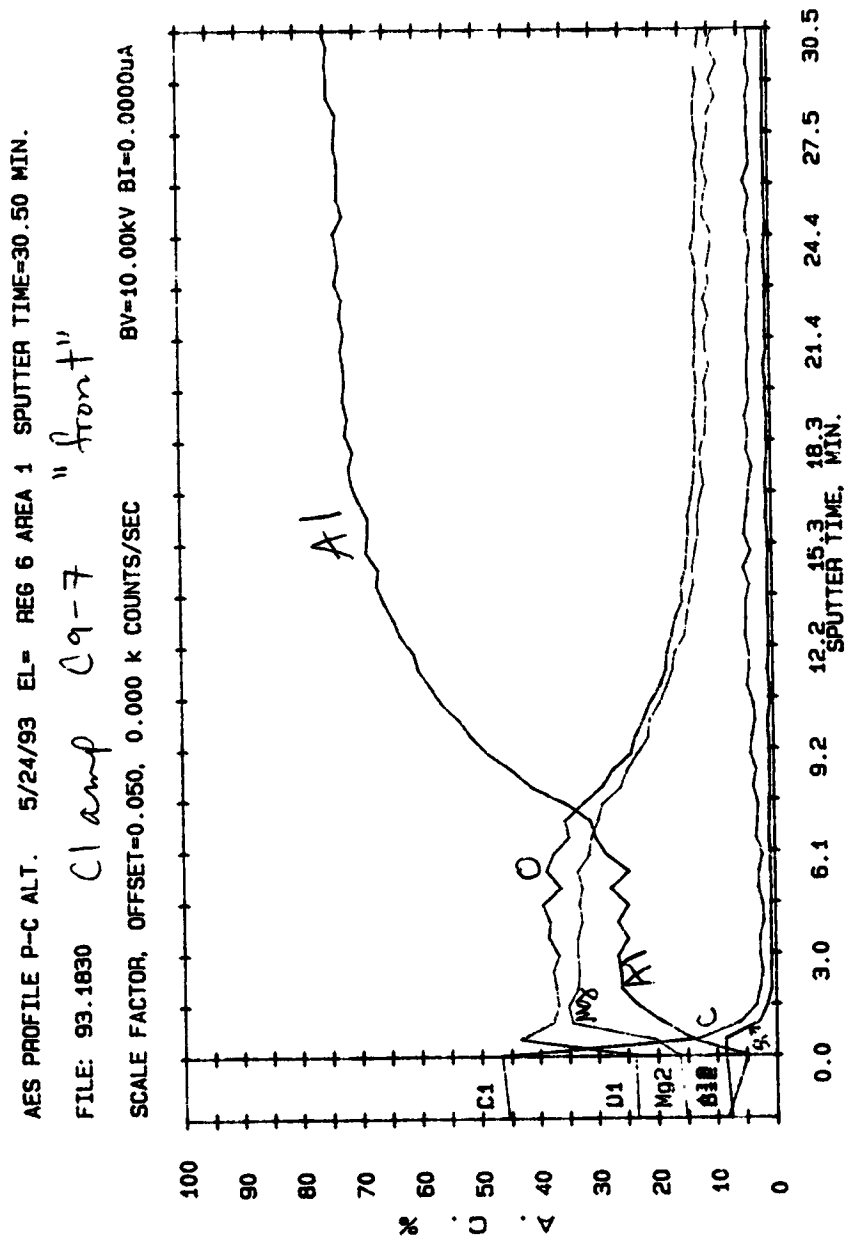


Figure B-5 Auger spectrum for front surface of tray clamp C9-7.

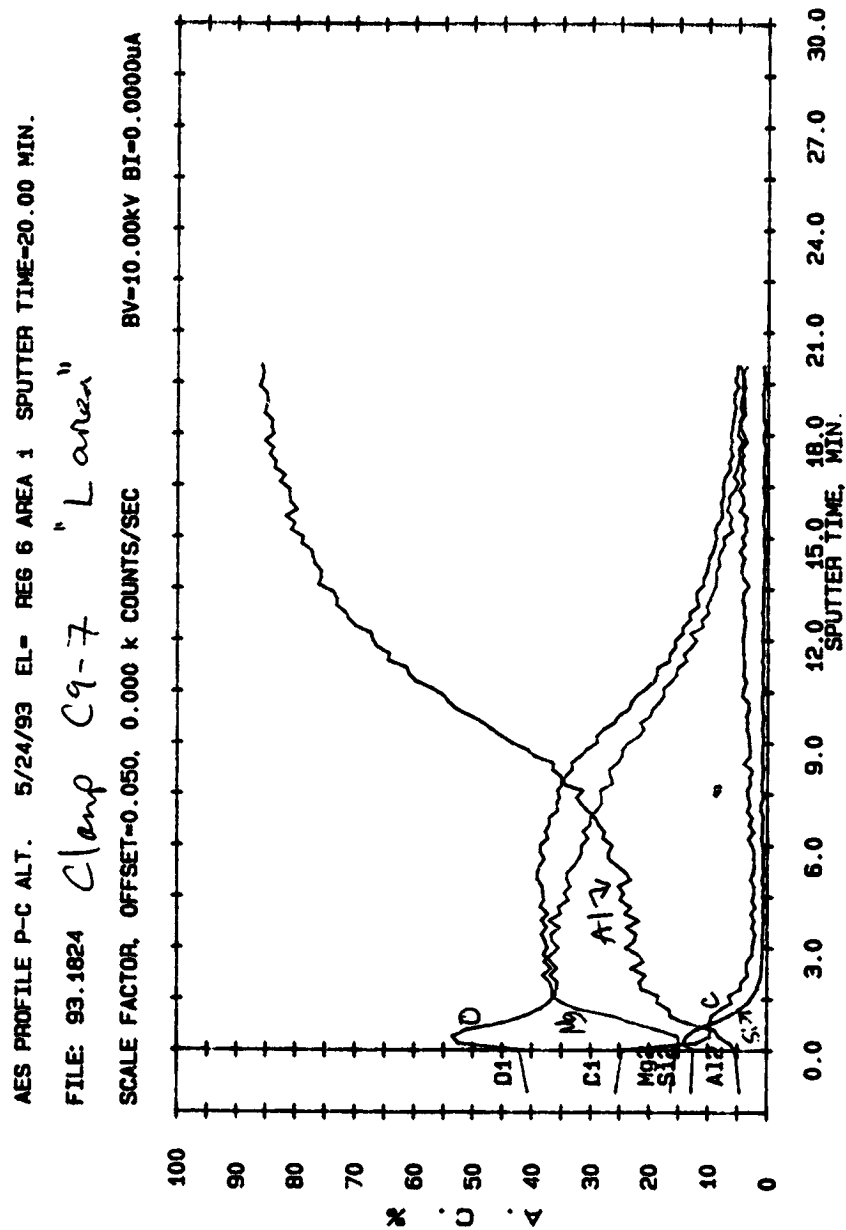


Figure B-6 Auger spectrum for "L area" of front surface of tray clamp C9-7.

AES PROFILE P-C ALT. 5/24/93 EL= REG 6 AREA 1 SPUTTER TIME=22.00 MIN.

FILE: 93.1836 Clap C9-7 "back"

SCALE FACTOR, OFFSET=0.050, 0.000 K COUNTS/SEC BV=10.00kV BI=0.0000uA

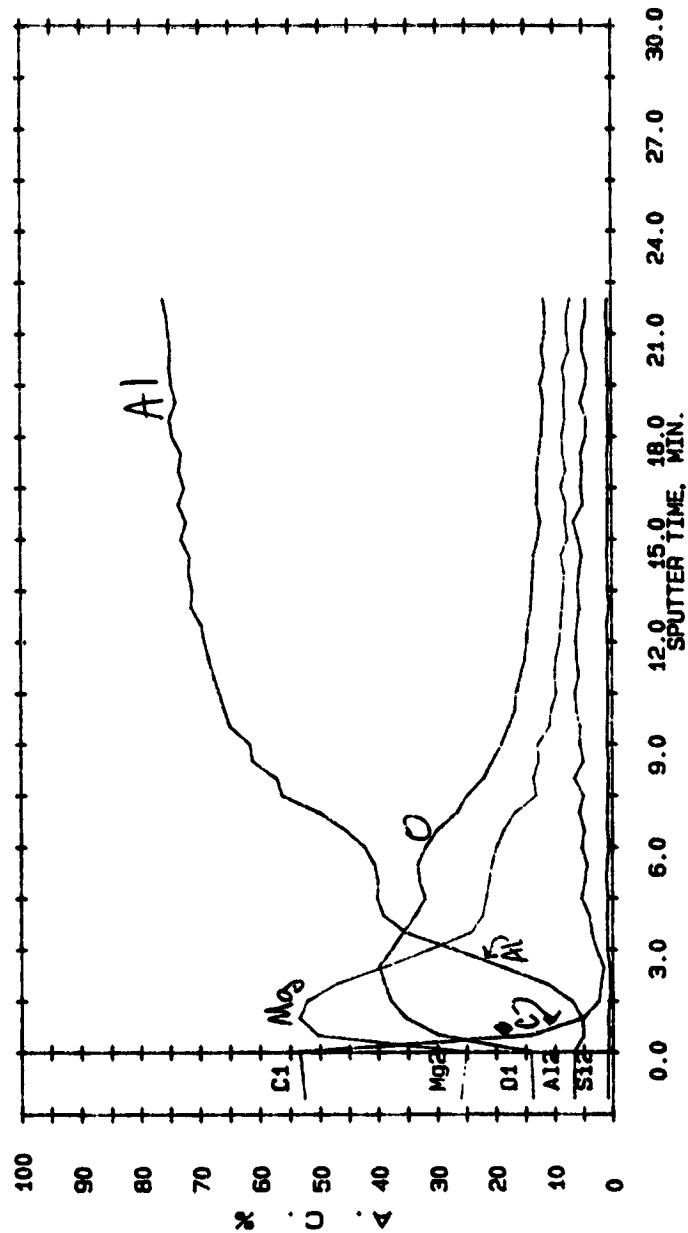


Figure B-7 Auger spectrum for back surface of tray clamp C9-7.

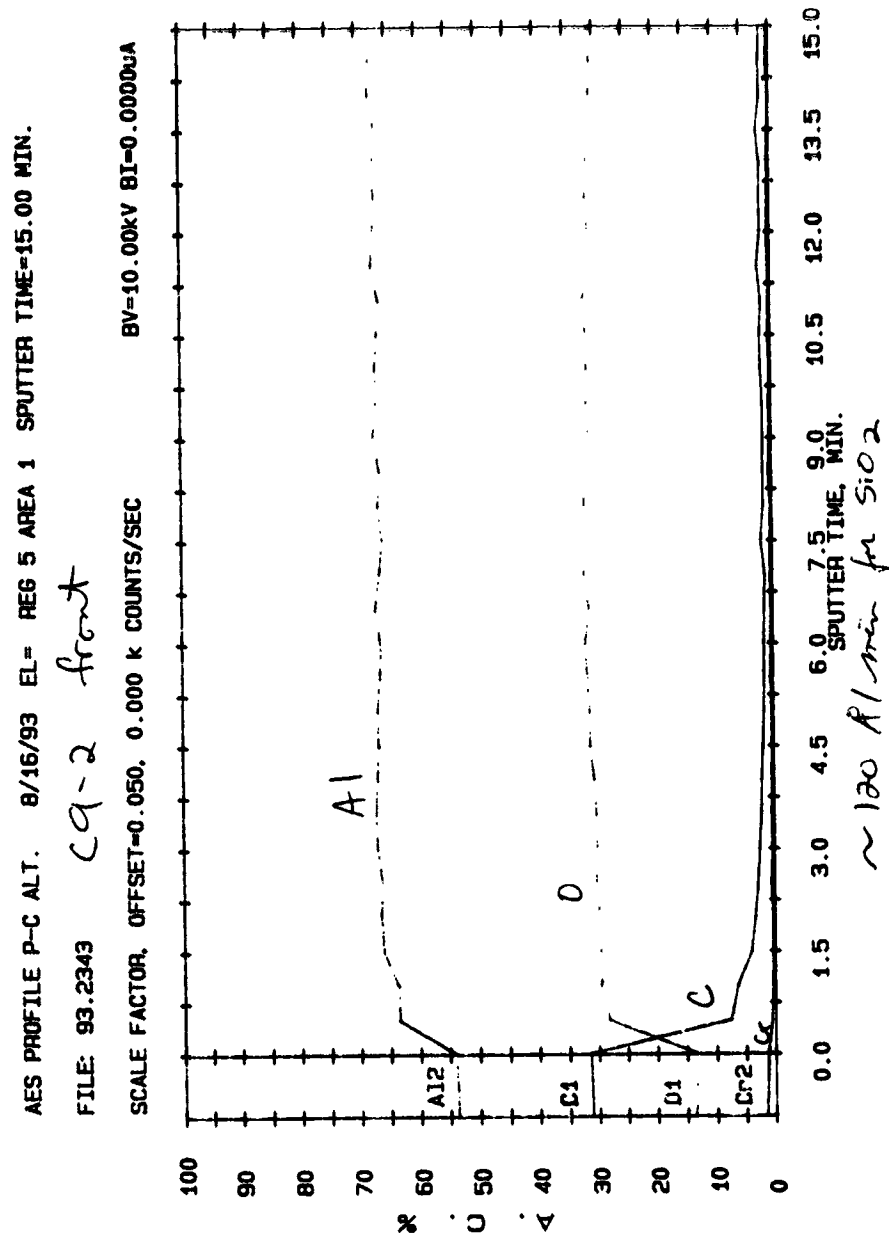


Figure B-8 Auger spectrum for front surface of tray clamp C9-2.

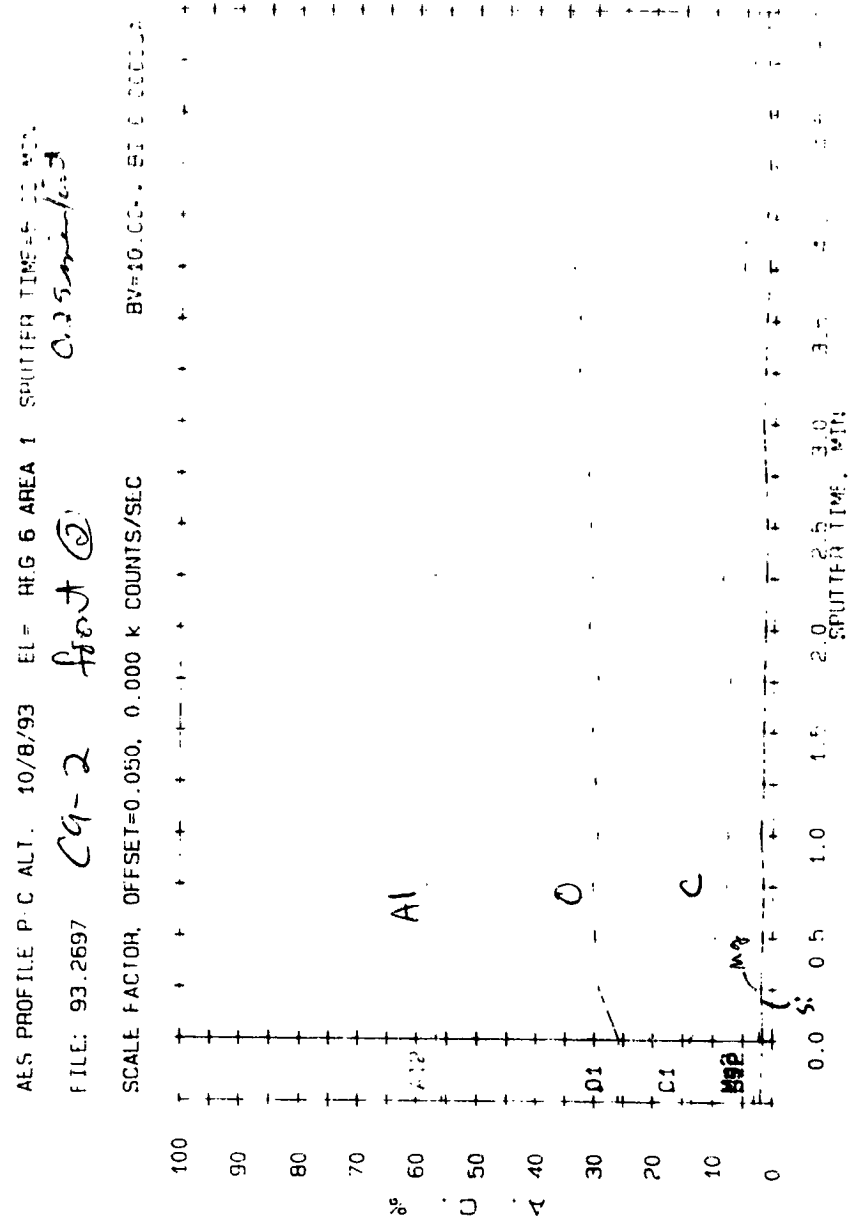


Figure B-9 Auger spectrum for second area from front surface of tray clamp C9-2.

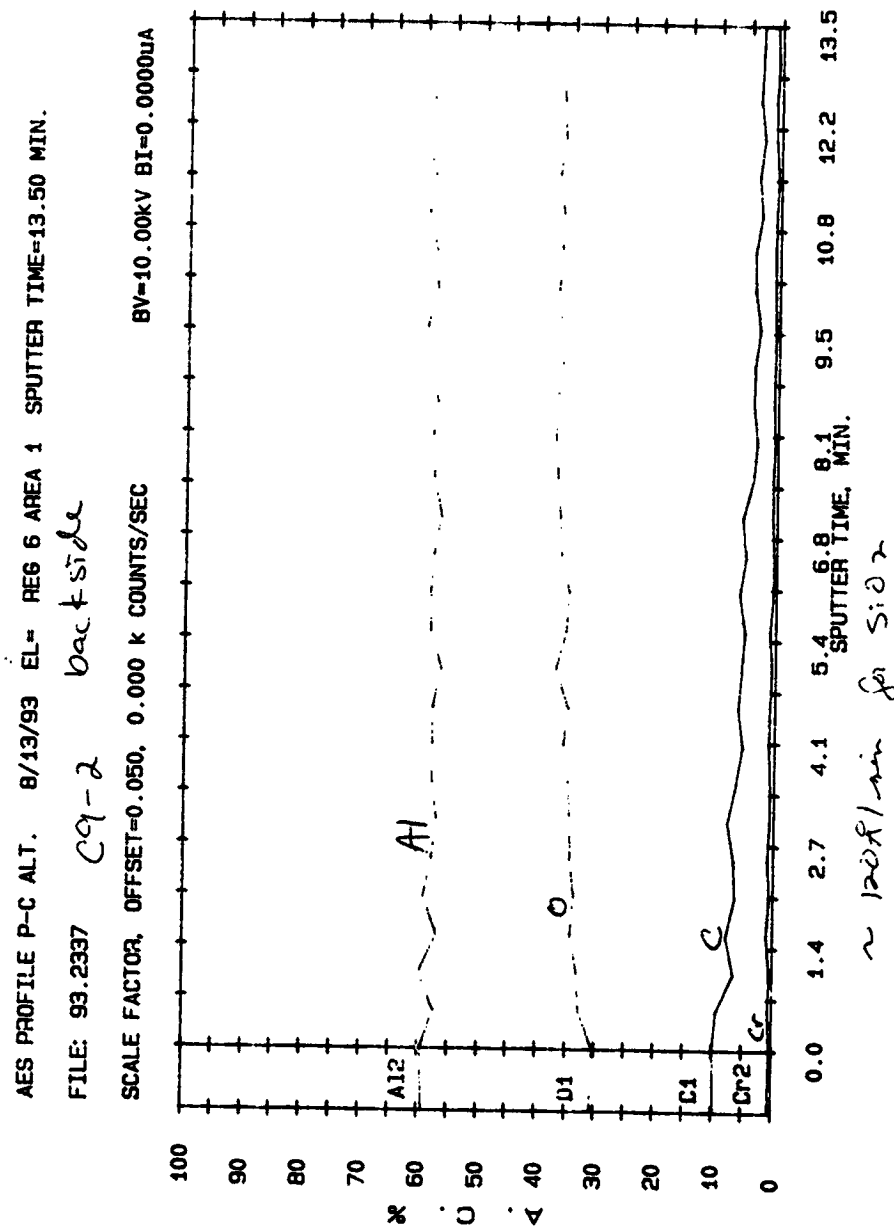


Figure B-10 Auger spectrum for back surface of tray clamp C9-2.

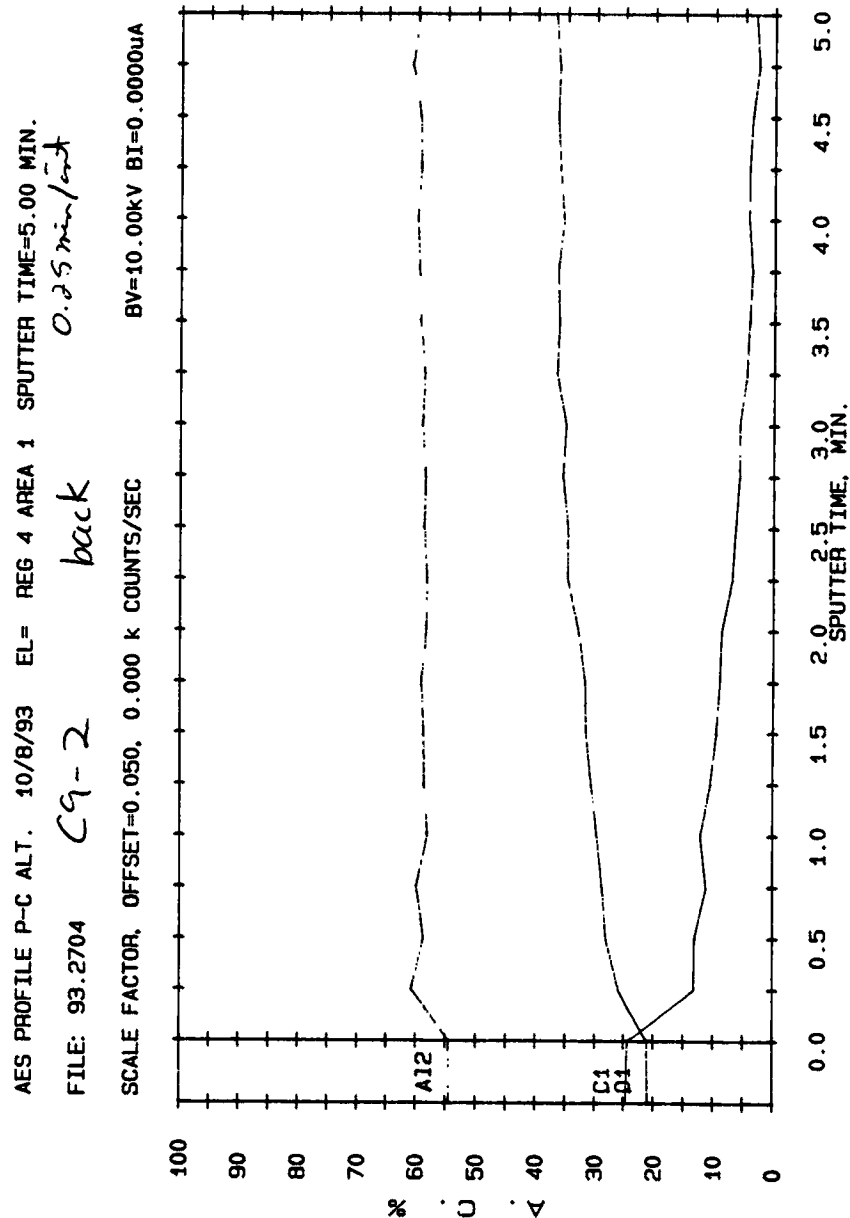


Figure B-11 Auger spectrum for second area from back surface of tray clamp C9-2.

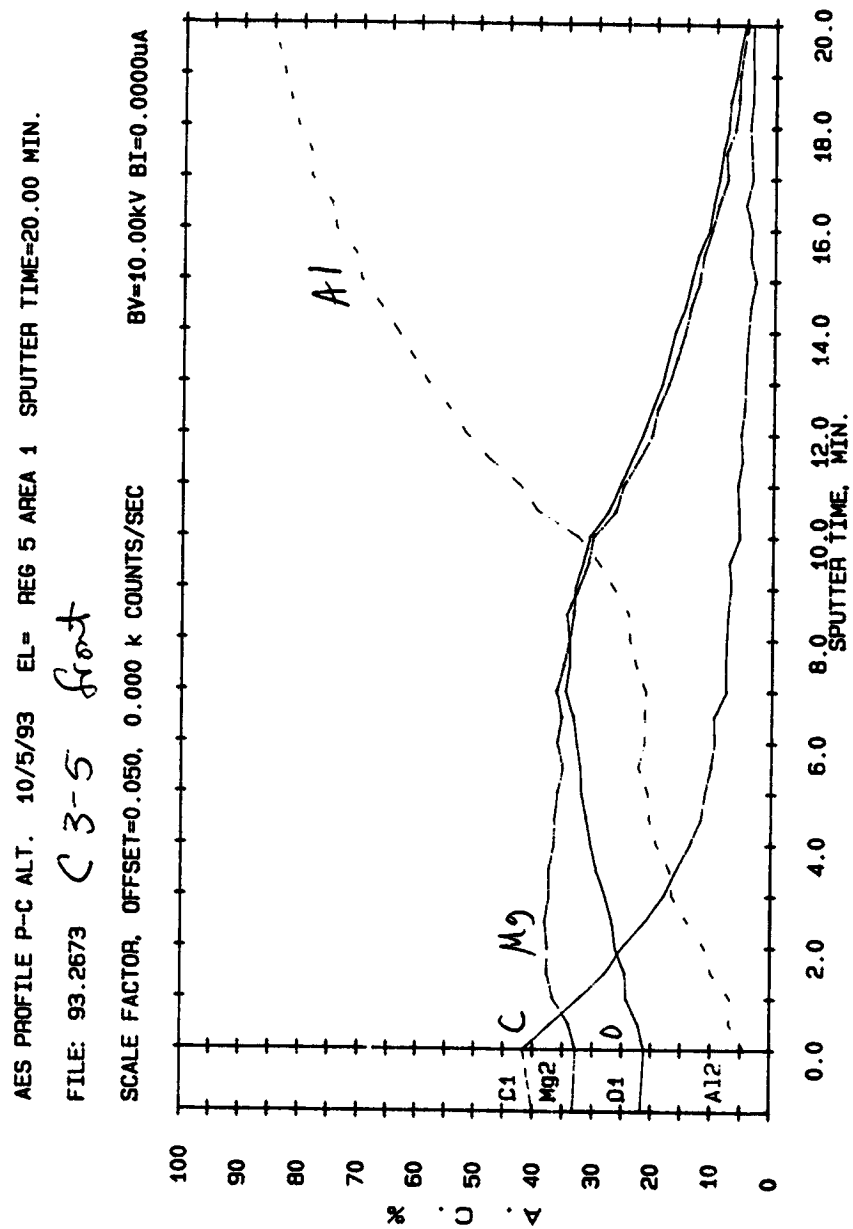


Figure B-12 Auger spectrum for front surface of tray clamp C3-5.

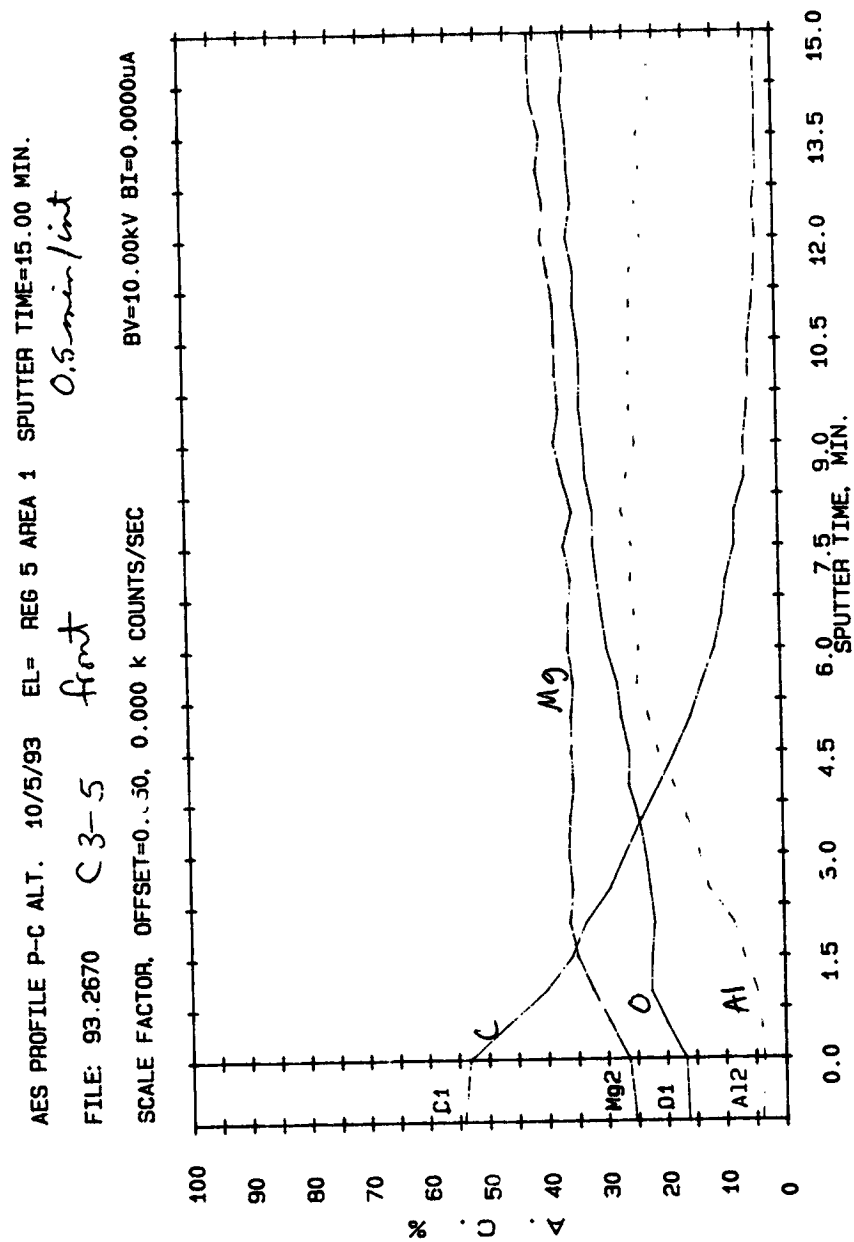


Figure B-13 Auger spectrum for second area from front surface of tray clamp C3-5.

AES PROFILE P-C ALT. 10/6/93 EL= REG 5 AREA 1 SPUTTER TIME=20.00 MIN.

FILE: 93.2680 C3-5 front

SCALE FACTOR, OFFSET=0.050, 0.000 k COUNTS/SEC

BV=10.00kV BI=0.0000uA

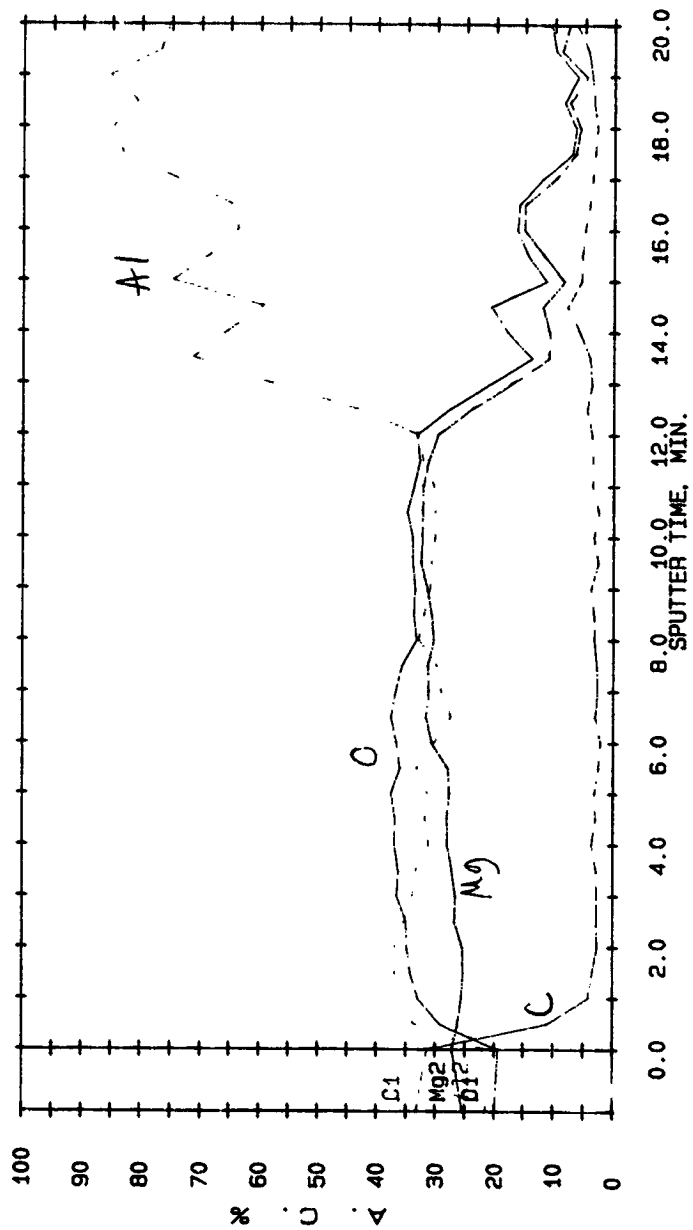


Figure B-14 Auger spectrum for third area from front surface of tray clamp C3-5.

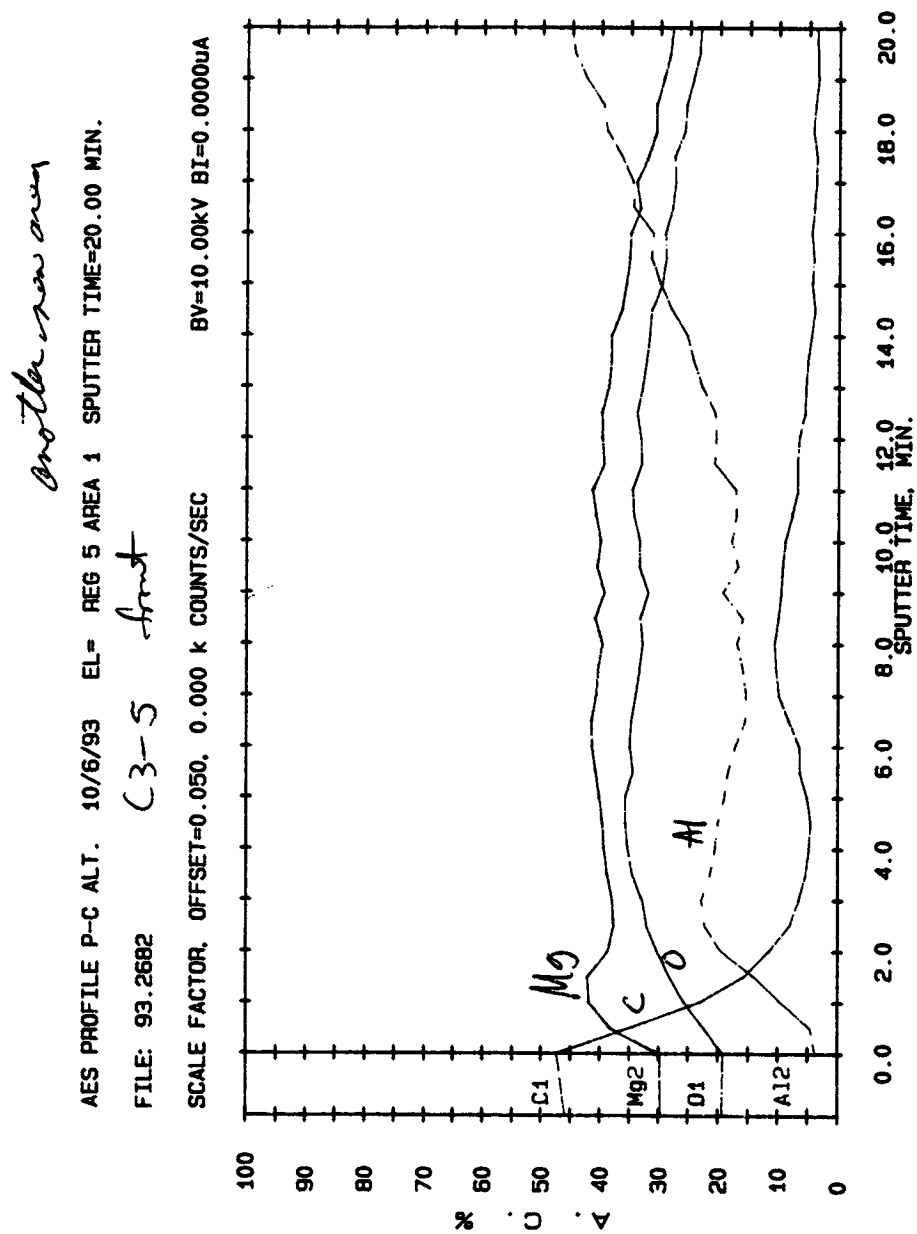


Figure B-15 Auger spectrum for fourth area from front surface of tray clamp C3-5.

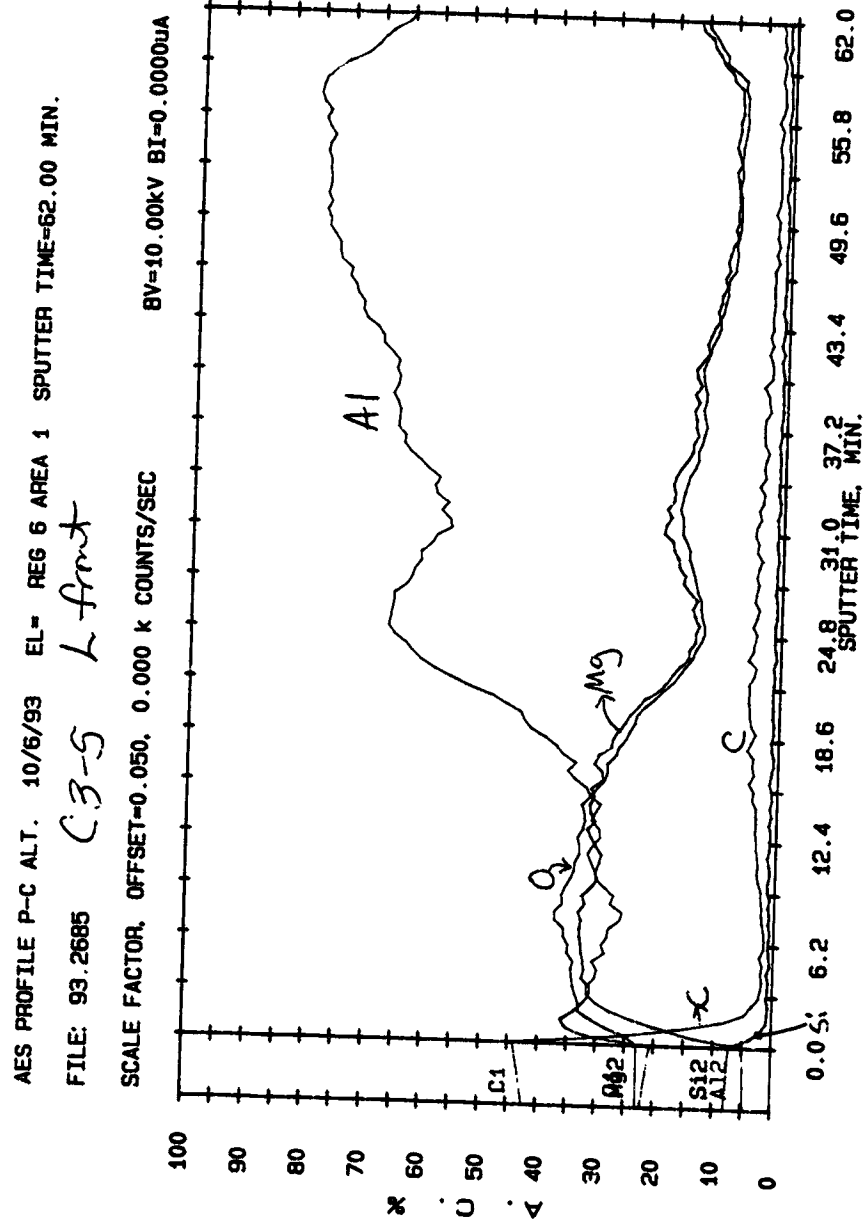


Figure B-16 Auger spectrum for "L area" of front surface of tray clamp C3-5.

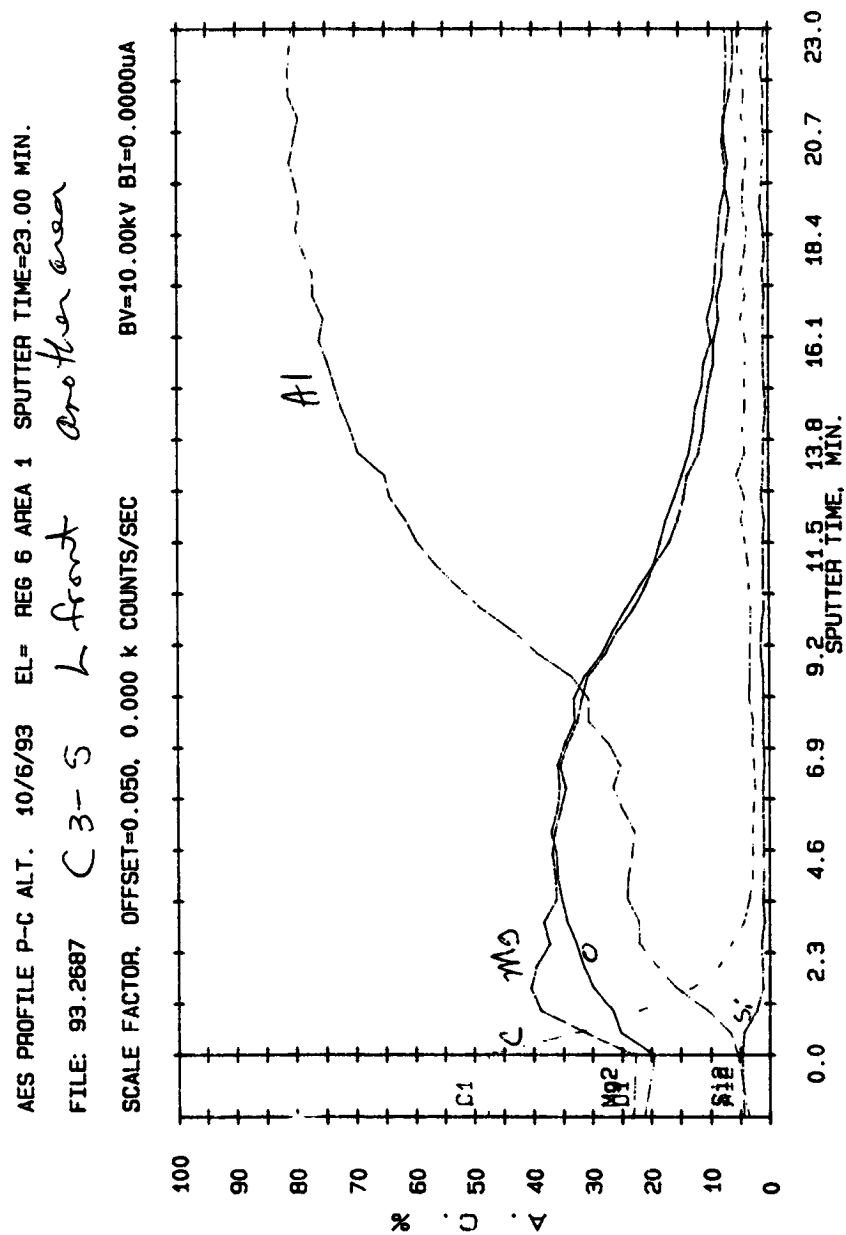


Figure B-17 Auger spectrum for second location in "L area" of front surface of tray clamp C3-5.

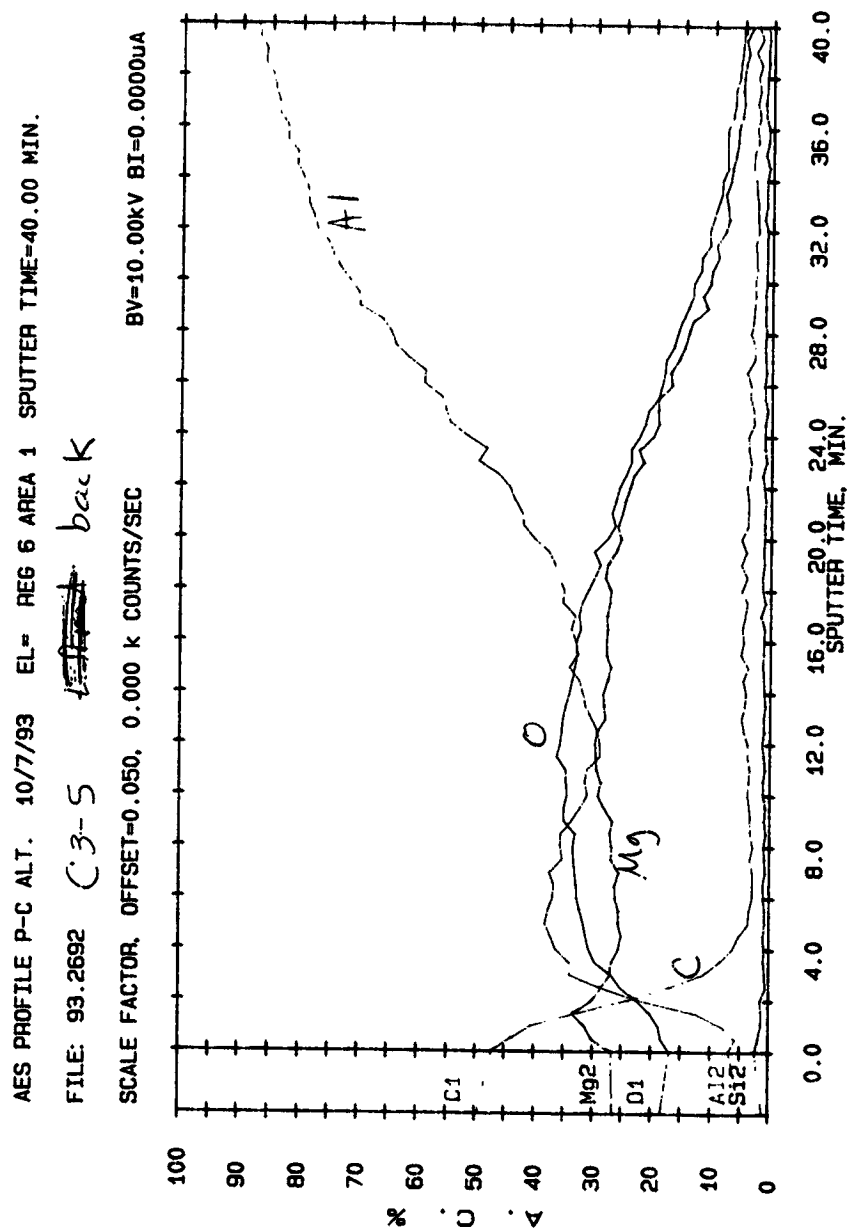


Figure B-18 Auger spectrum for back surface of tray clamp C3-5.

Appendix C

Auger Spectra for Bolts from Selected Aluminum Tray Clamps.

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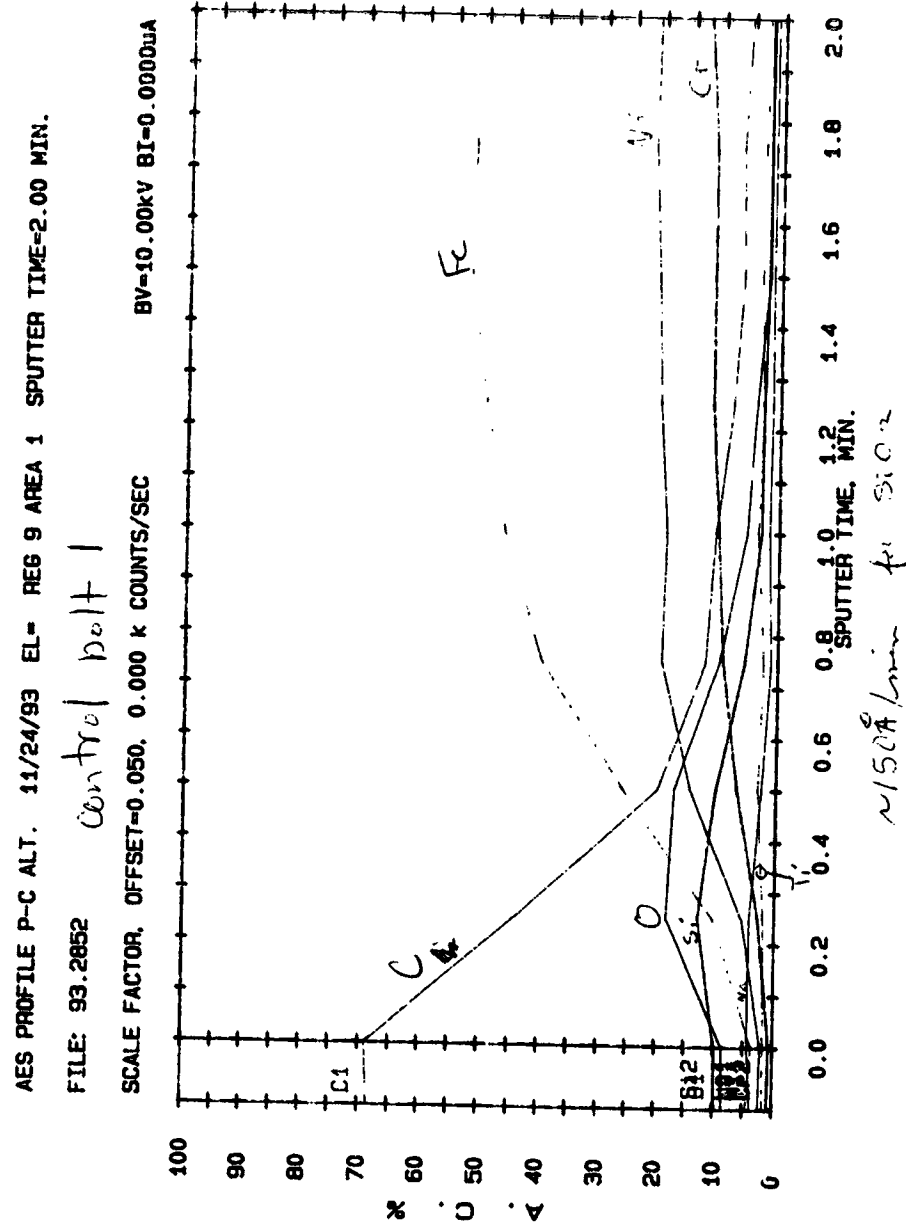


Figure C-1 Auger spectra from area of bolt head of control bolt 1.

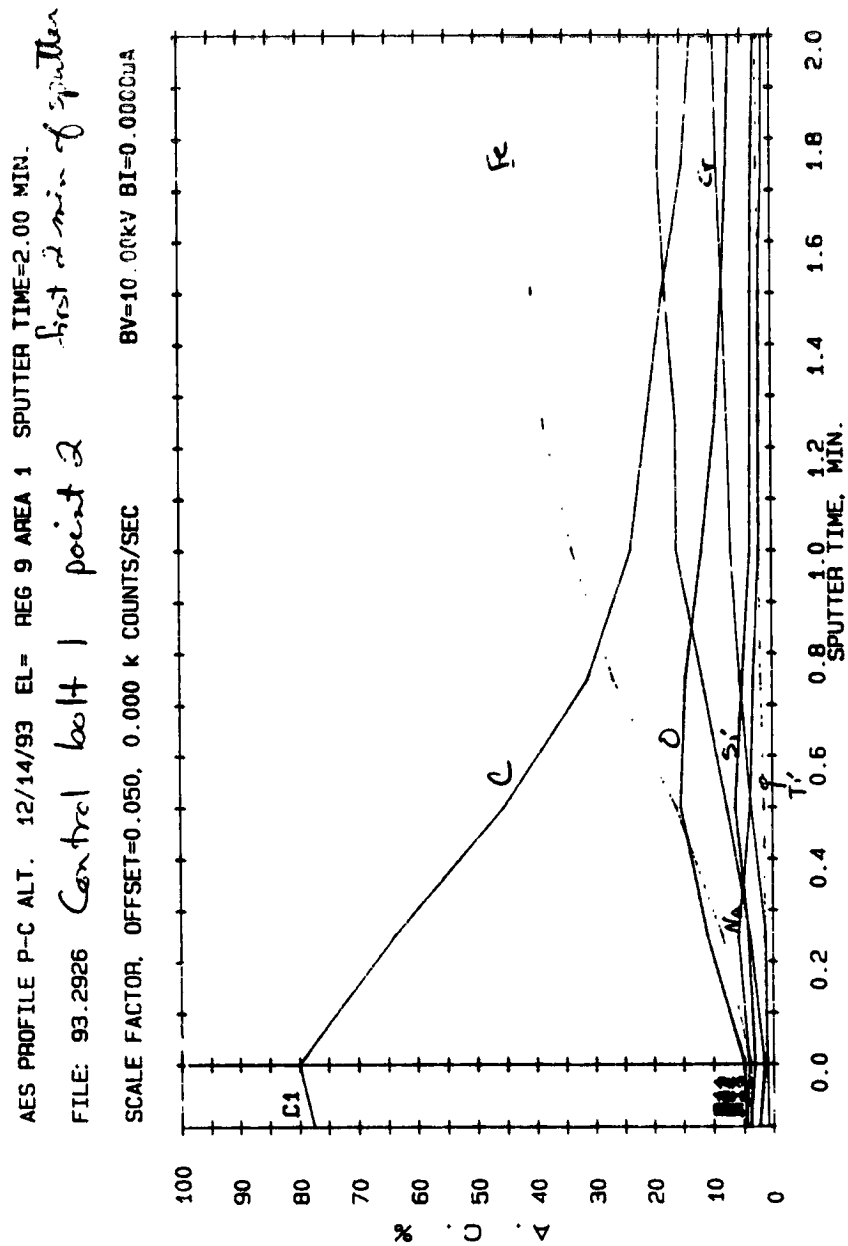


Figure C-2 Auger spectra from second area of bolt head of control bolt 1.

AES PROFILE P-C ALT. 11/24/93 EL- REG 9 AREA 1 SPUTTER TIME=4.00 MIN.

FILE: 93.2855 Control bolt 2

SCALE FACTOR, OFFSET=0.050, 0.000 K COUNTS/SEC BV=10.00KV BI=0.0000UA

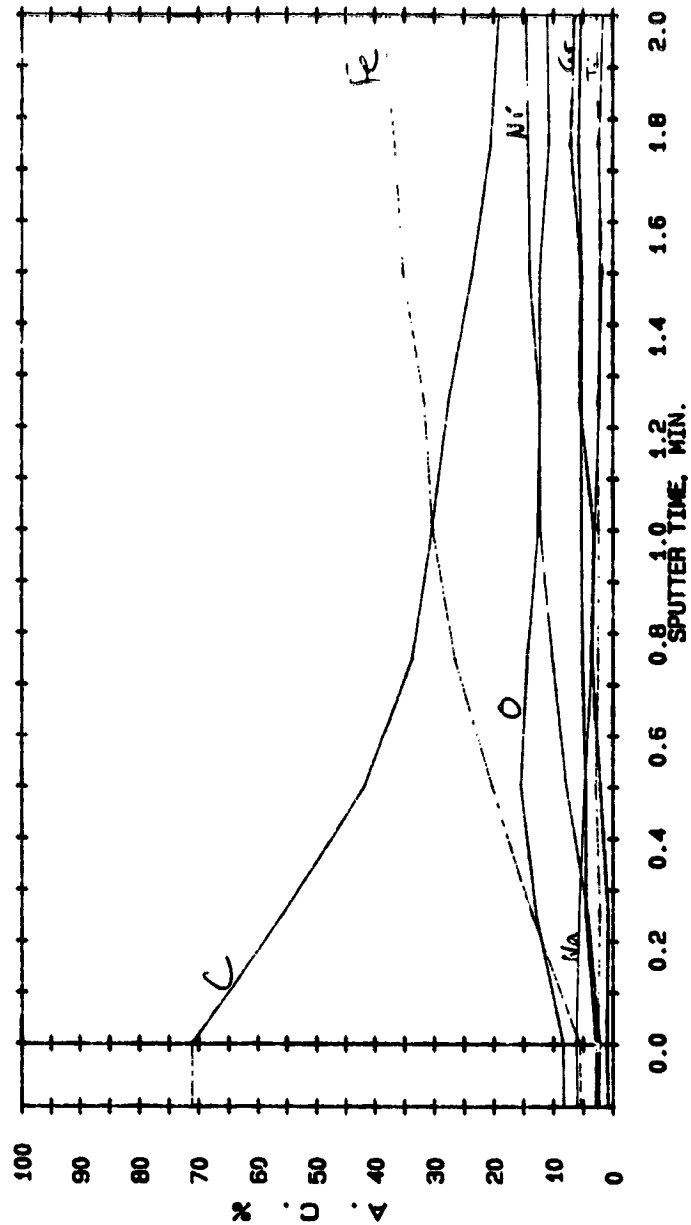


Figure C-3 Auger spectra from area of bolt head of control bolt 2.

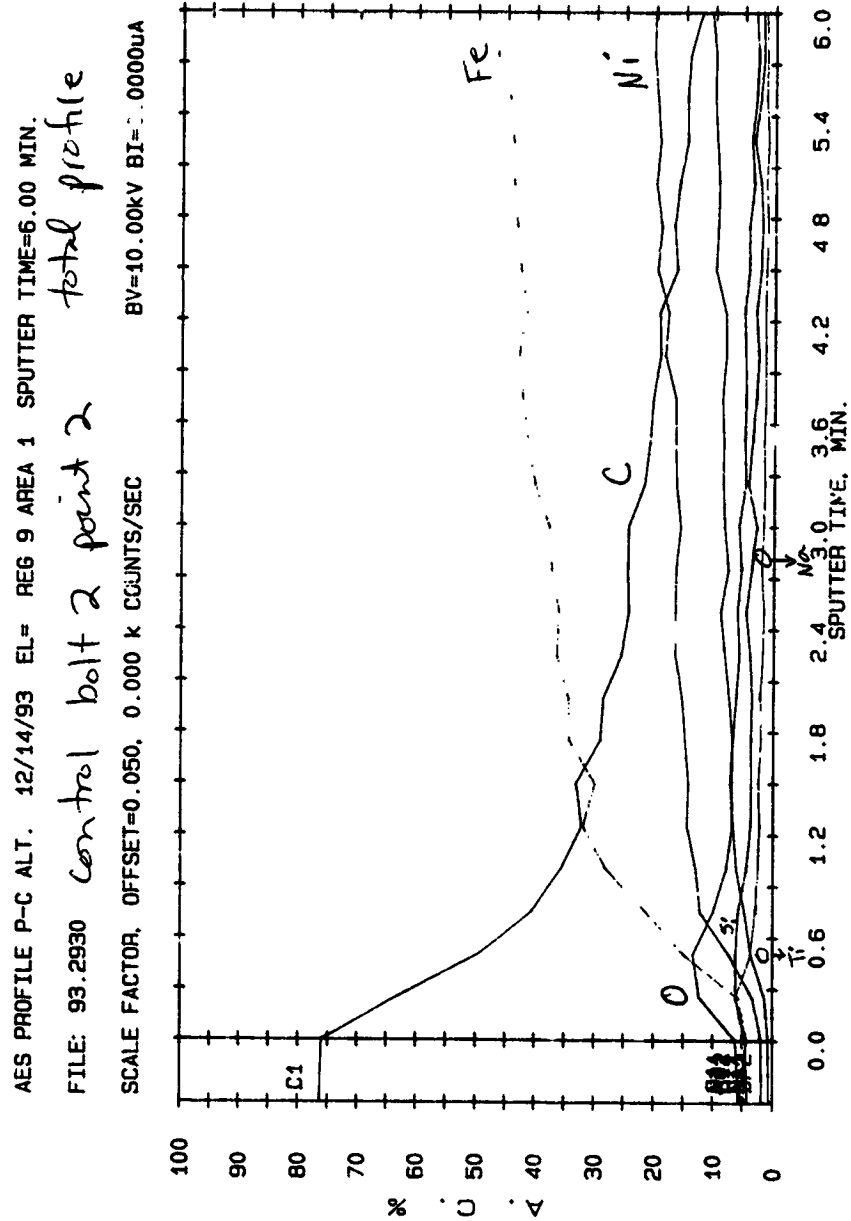


Figure C-4 Auger spectra from second area of bolt head of control bolt 2.

AES PROFILE P-C ALT. 12/15/93 EL= REG 9 AREA 1 SPUTTER TIME=2.00 MIN.

FILE: 93.2955 Control bolt 3 point 1

SCALE FACTOR, OFFSET=0.050, 0.000 k COUNTS/SEC BV=10.00kV BI=0.0000uA

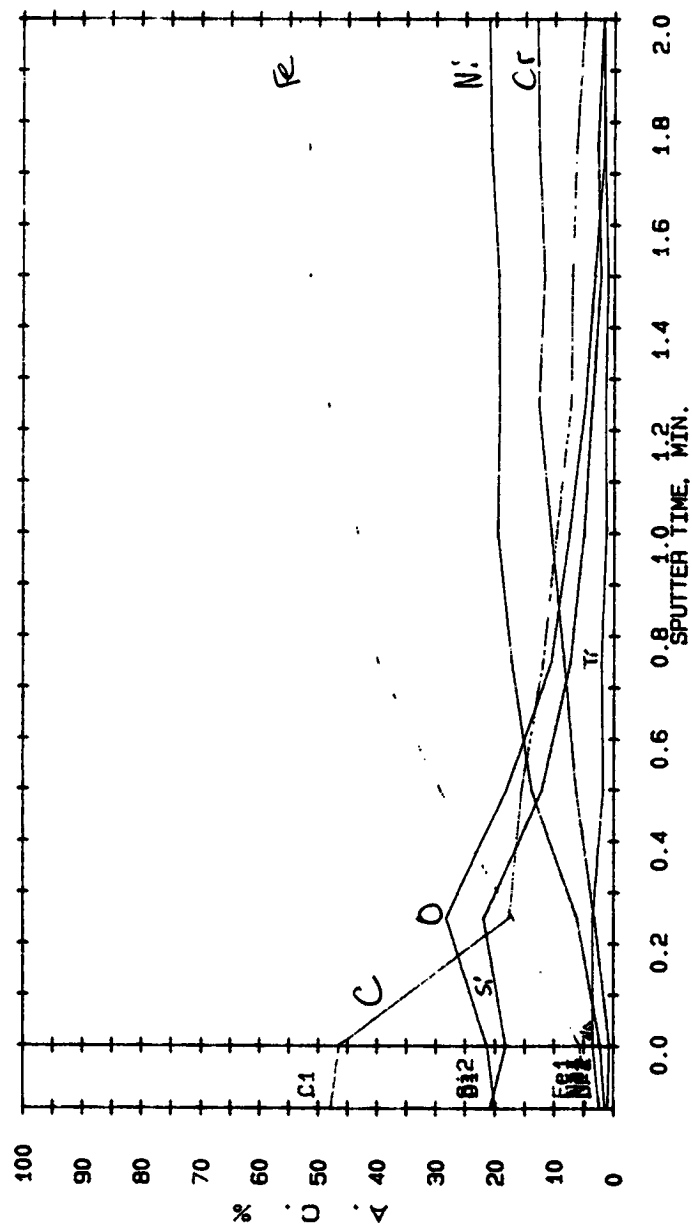


Figure C-5 Auger spectra from area of bolt head of control bolt 3.

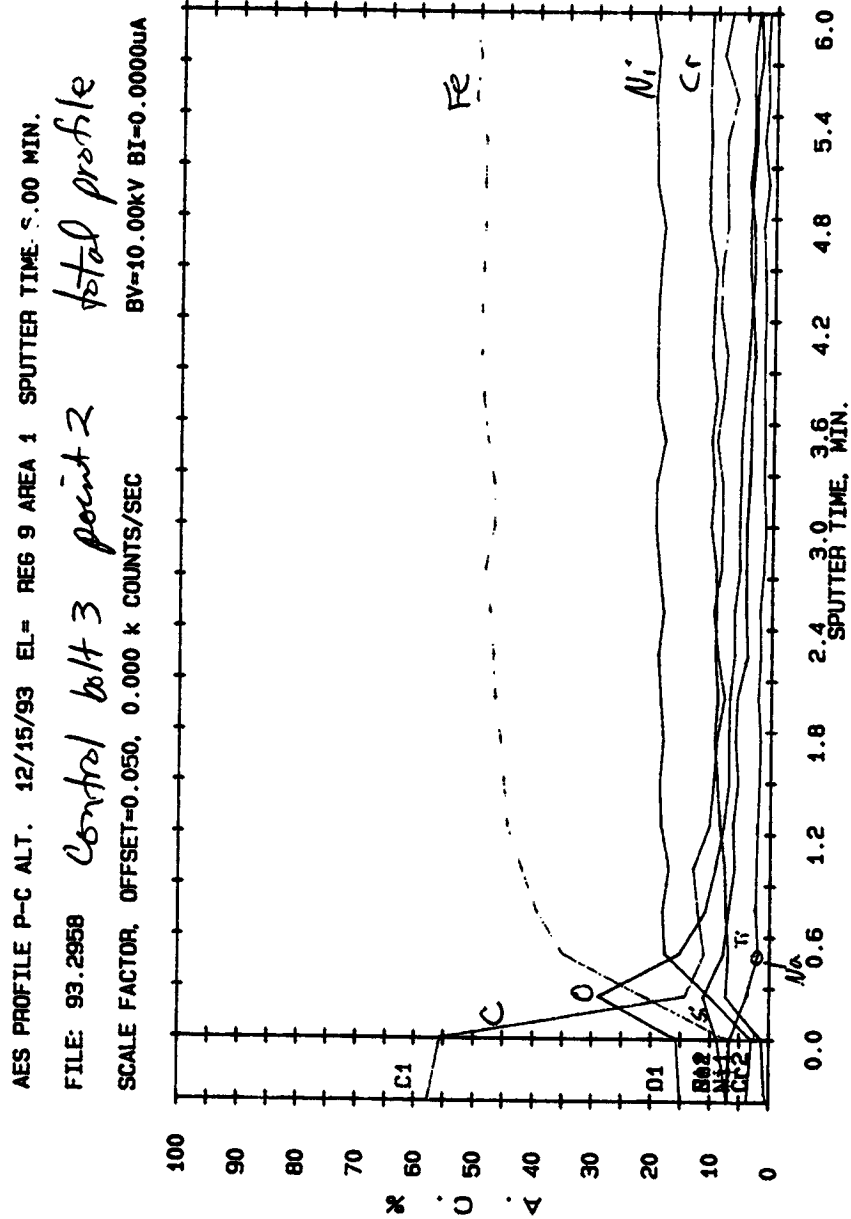


Figure C-6 Auger spectra from second area of bolt head of control bolt 3.

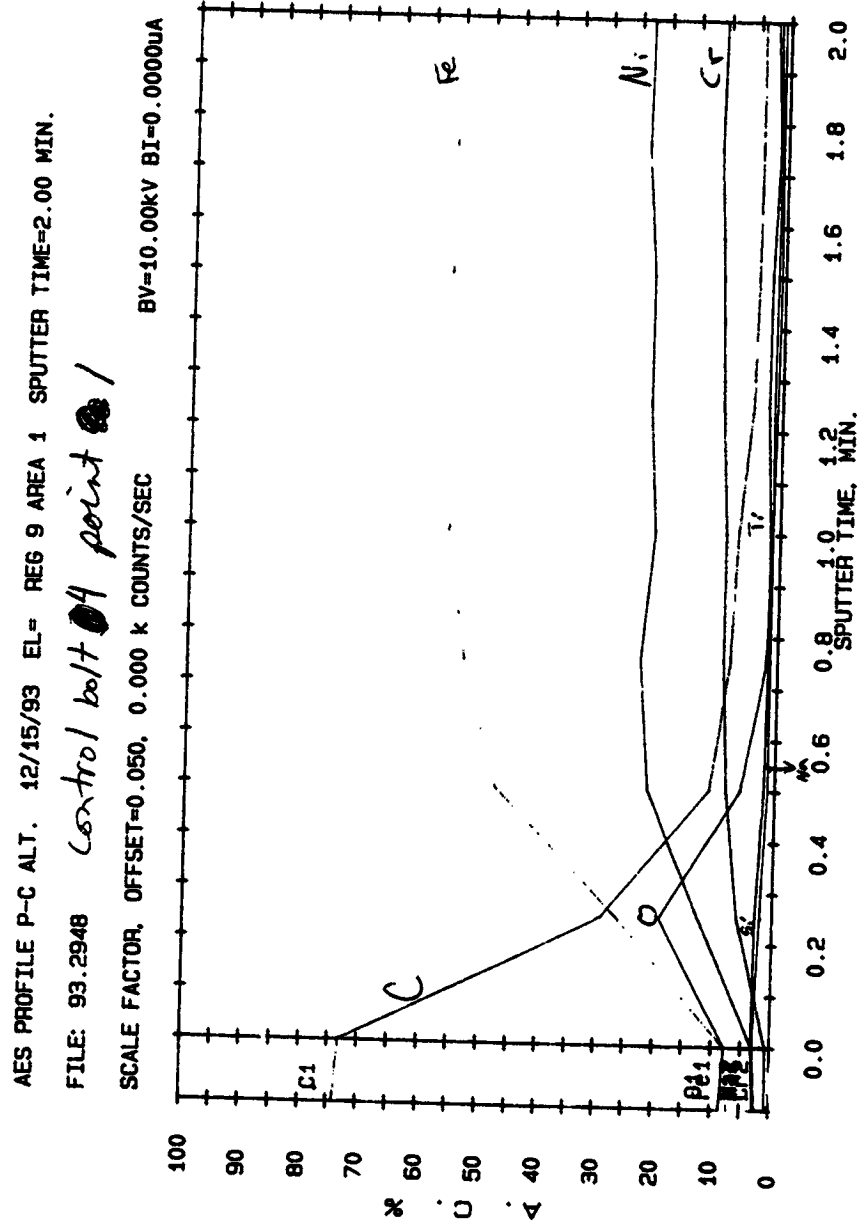


Figure C-7 Auger spectra from area of bolt head of control bolt 4.

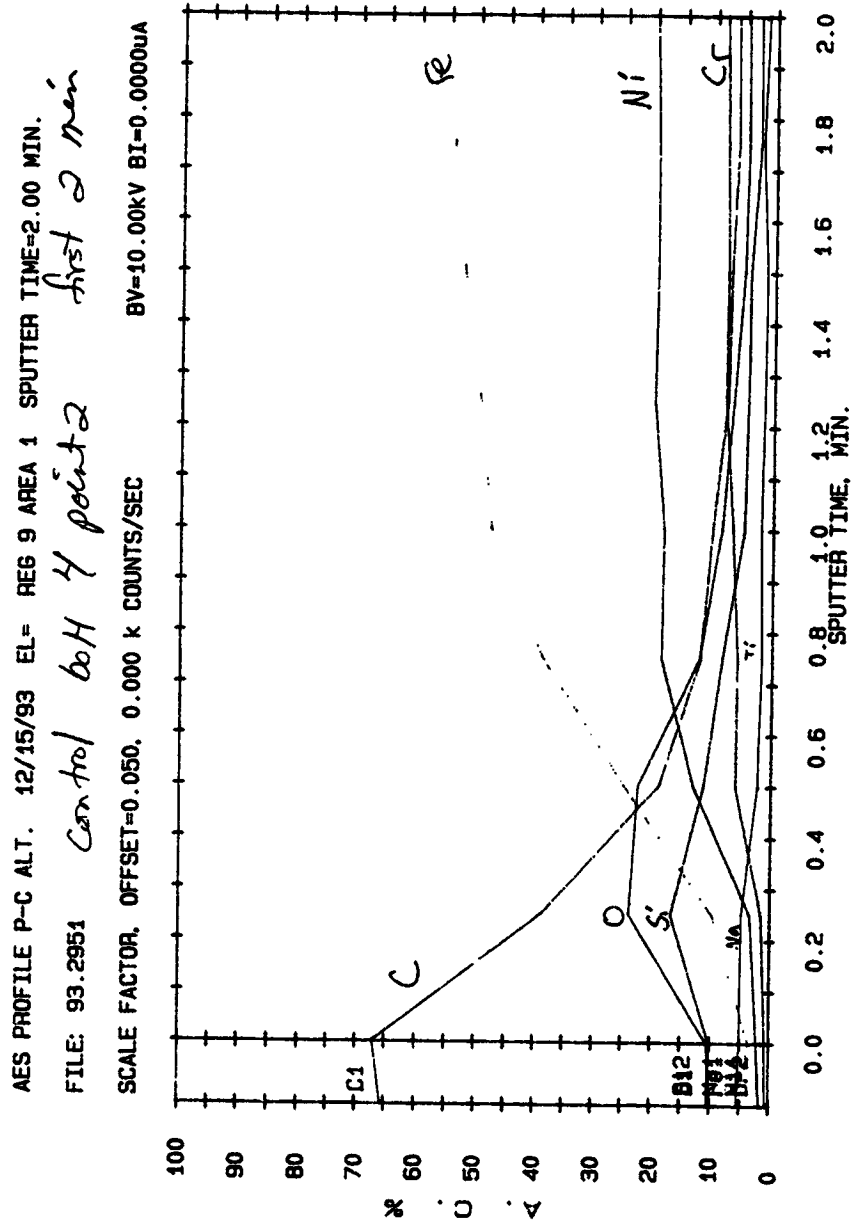


Figure C-8 Auger spectra from second area of bolt head of control bolt 4.

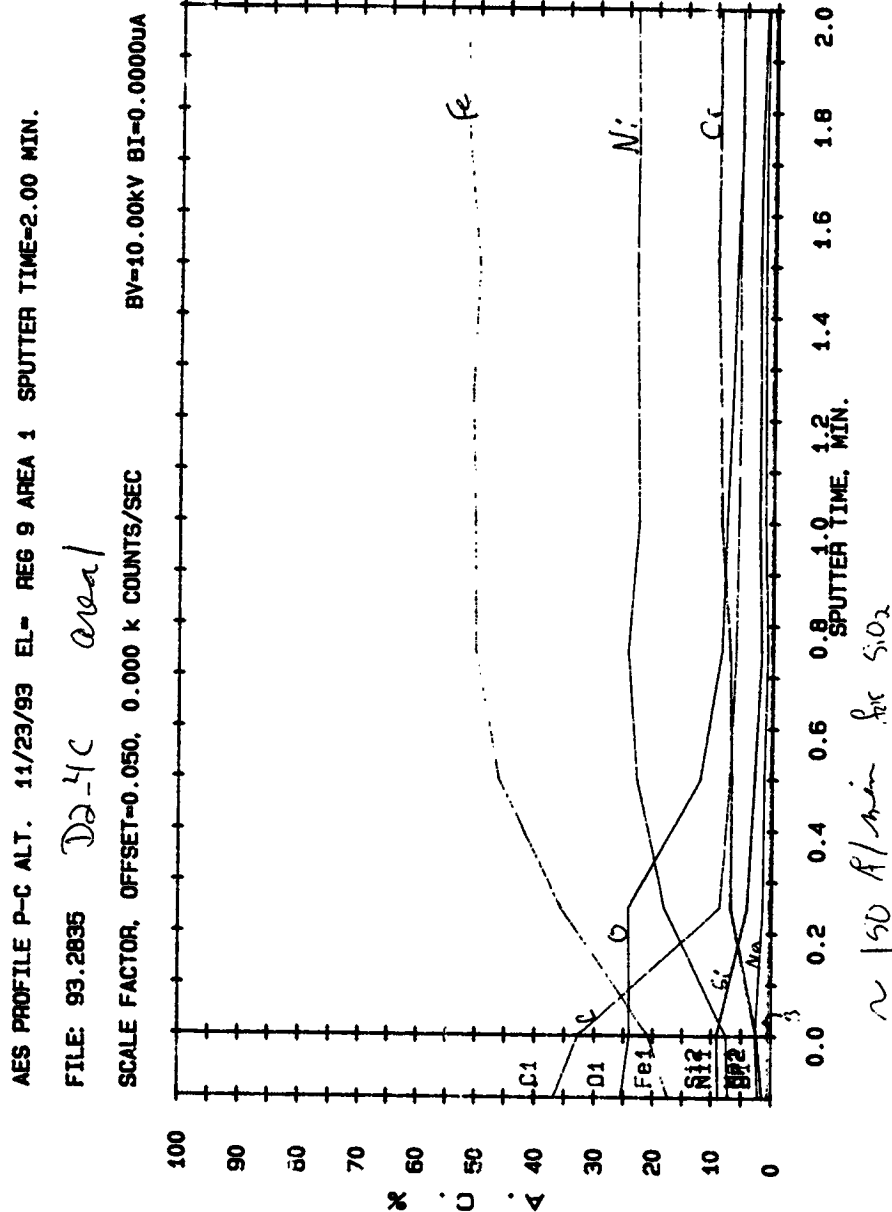


Figure C-9 Auger spectra from area of bolt head of bolt D2, 4c-1.

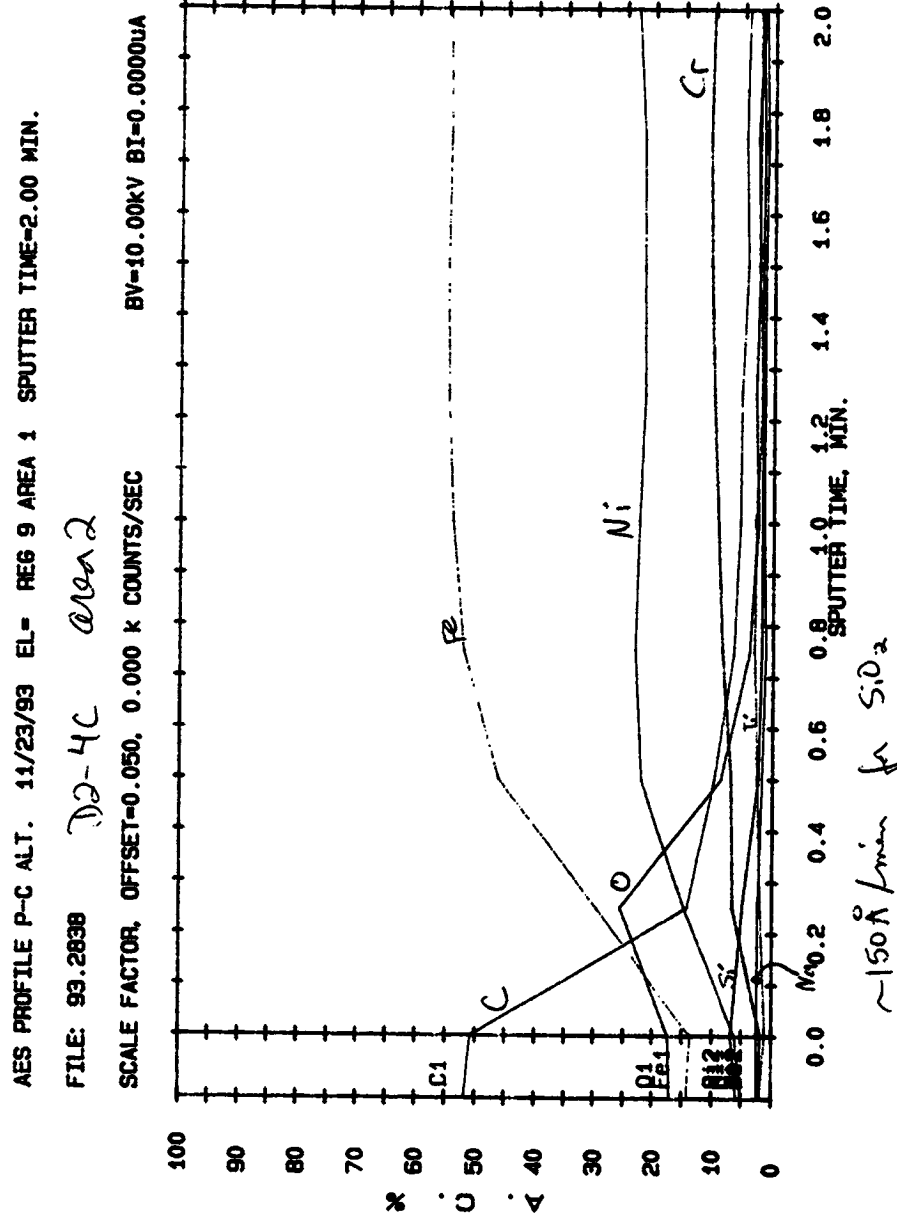


Figure C-10 Auger spectra from second area of bolt head of bolt D2, 4c-2.

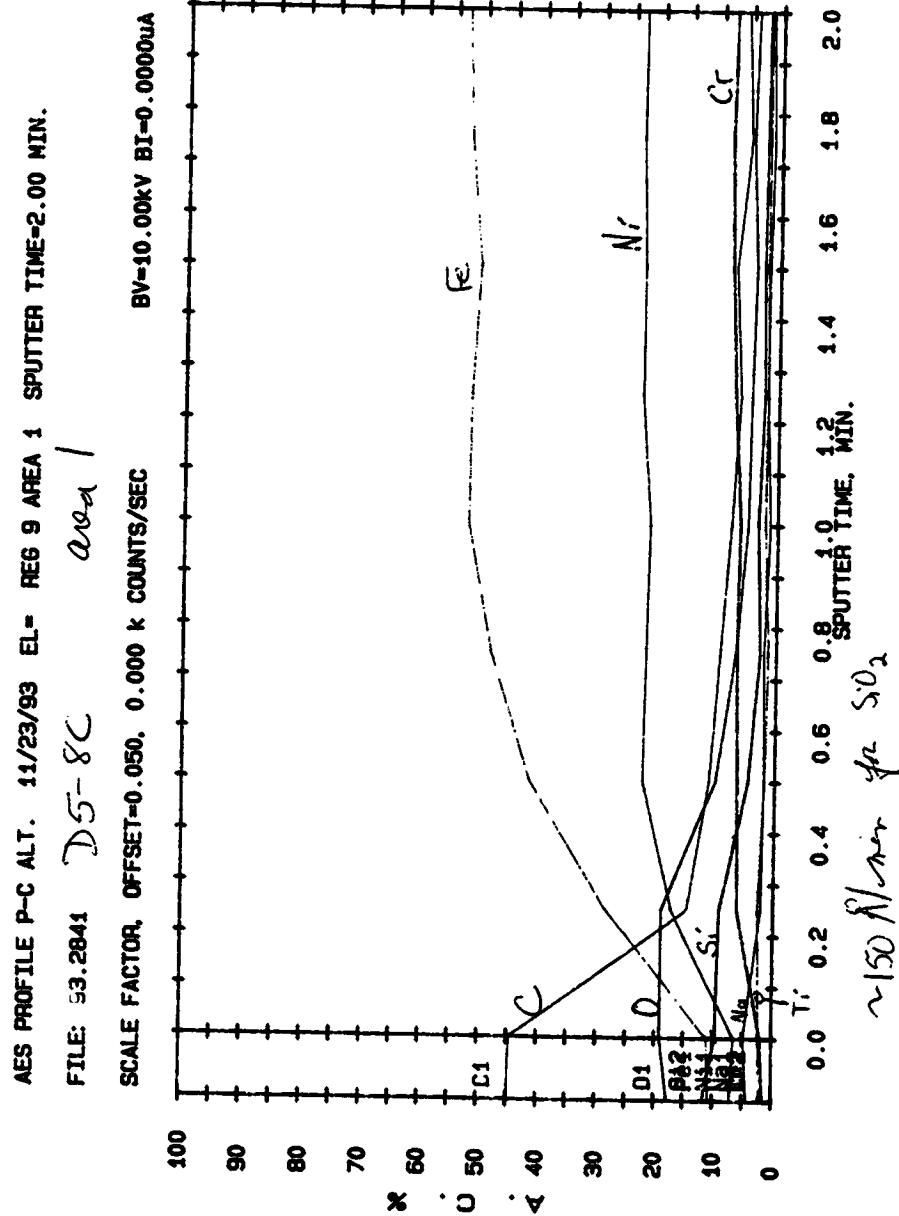


Figure C-11 Auger spectra from area of bolt head of bolt D5, 8c-1.

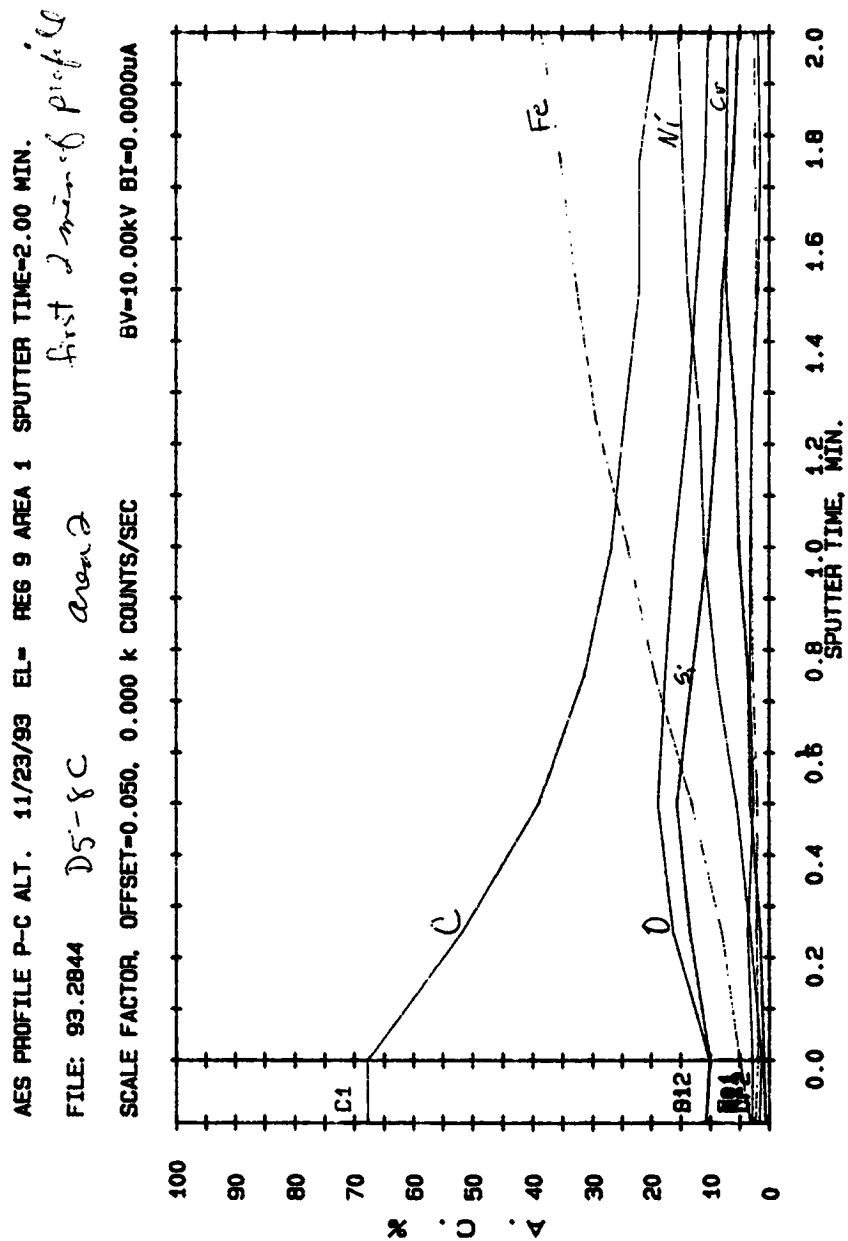


Figure C-12 Auger spectra from second area of bolt head of bolt D5, 8c-2.

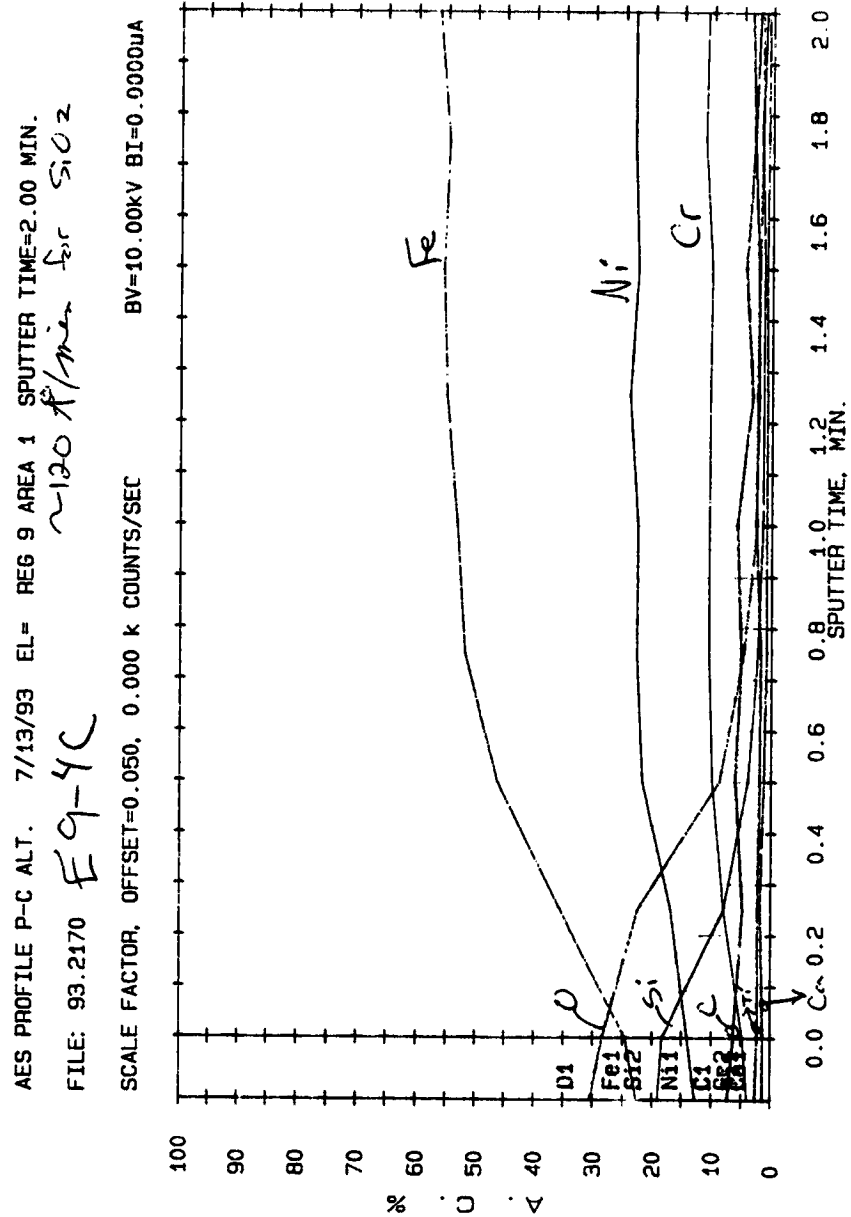


Figure C-13 Auger spectra from area of bolt head of bolt E9, 4c.

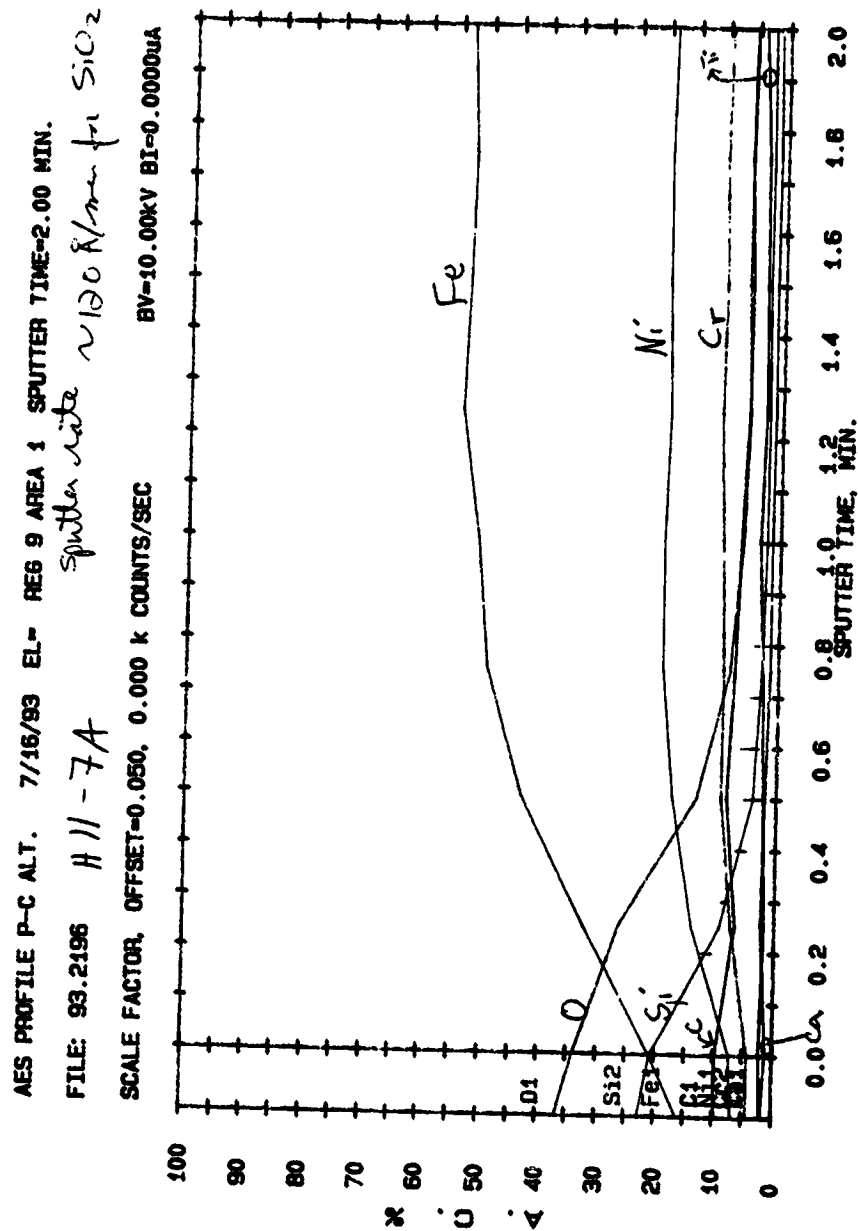


Figure C-14 Auger spectra from area of bolt head of bolt H11, 7a.

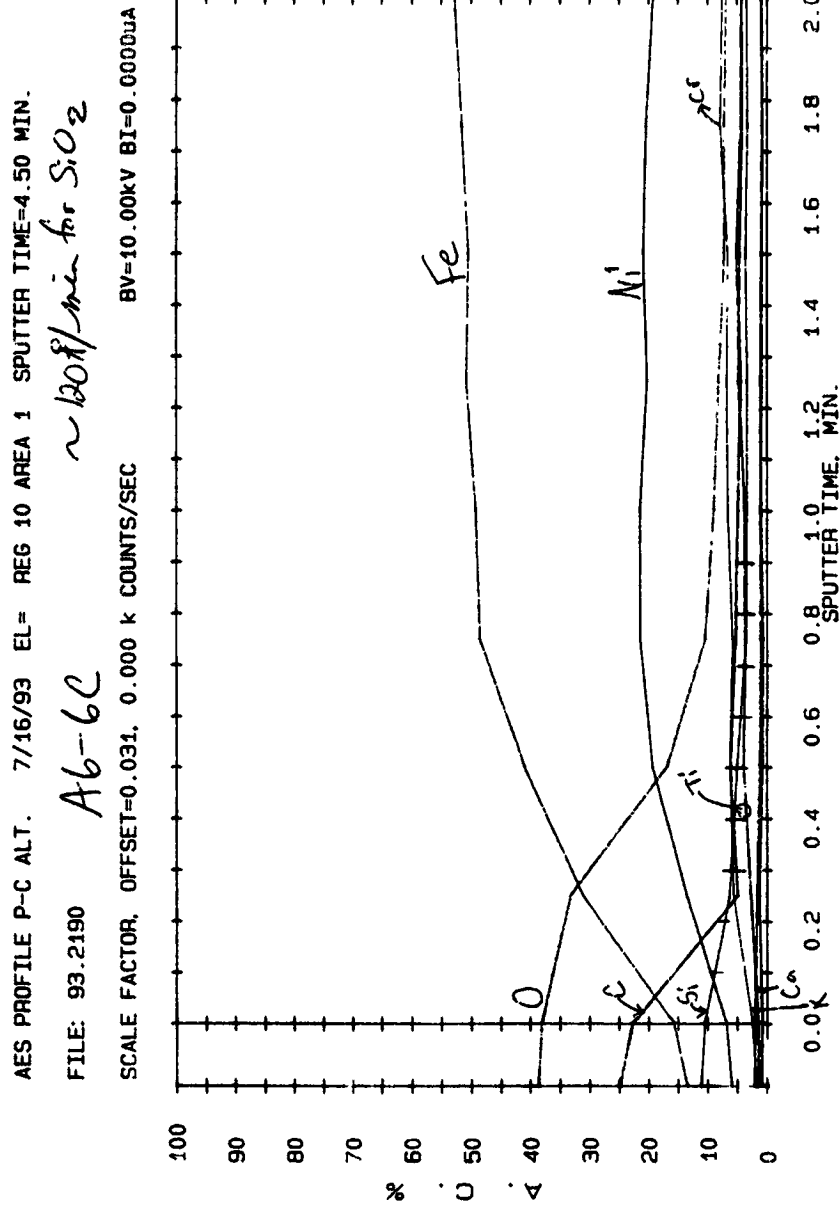


Figure C-15 Auger spectra from area of bolt head of bolt D7, 7a.

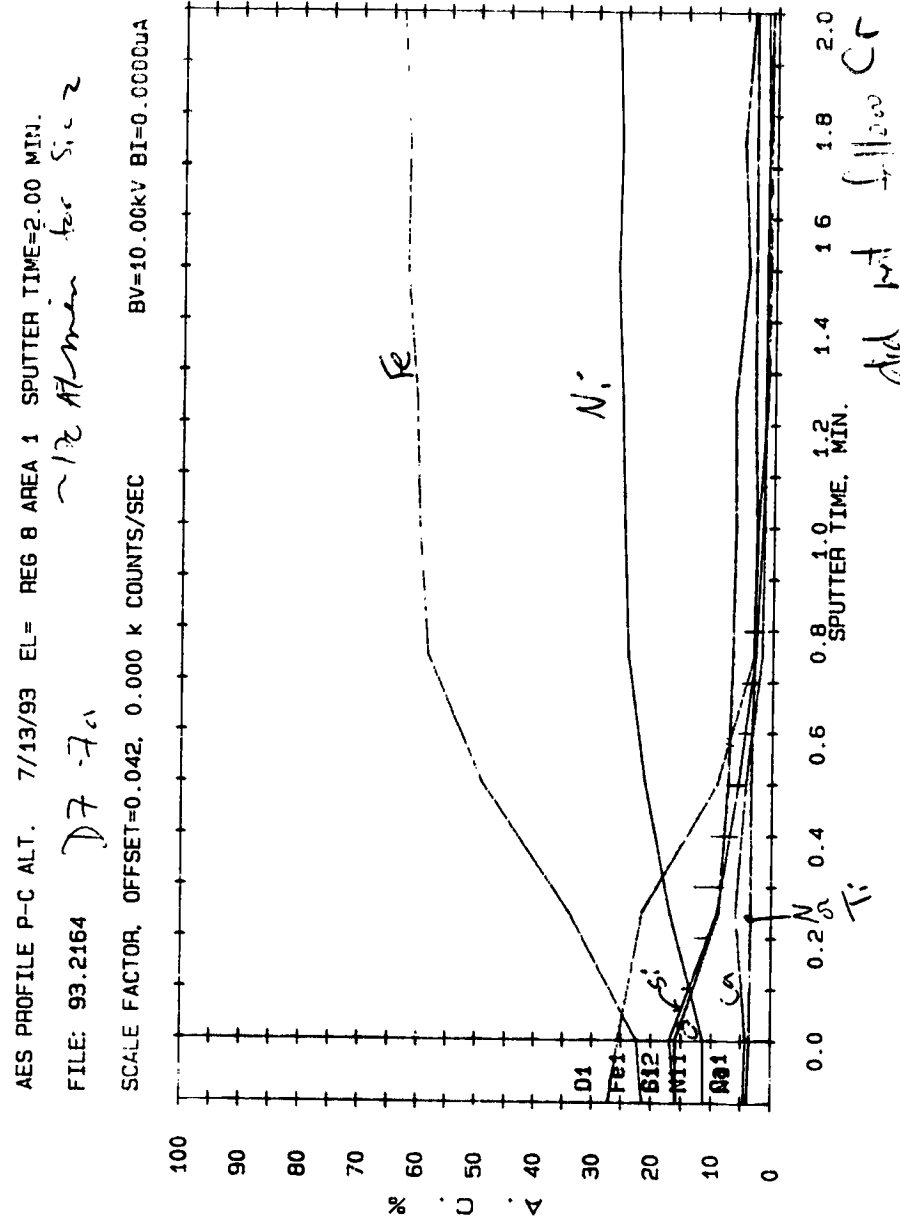


Figure C-16 Auger spectra from area of bolt head of bolt A6, 6c.

Appendix D

ESCA Spectra from Copper Surfaces

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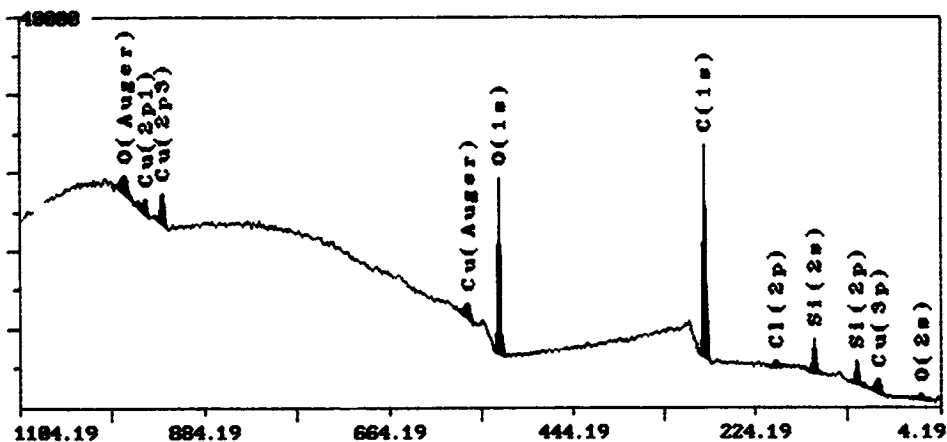
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Mon May 18 08:56:16 M-Probe ESCA Console User ID: MELISSA
 CUSTRP02.MRS Mon May 18 08:58:57 1992 Operator: M D JOHNSON
 LDEF - ORIGINAL CU STRIP
 Spot: 488x1888p Resolution: 3 Energy:
 Scans: 28 of 28 Neutralizer: 8.8eV Counts:
 Region: 1/ 1 Aperture: None



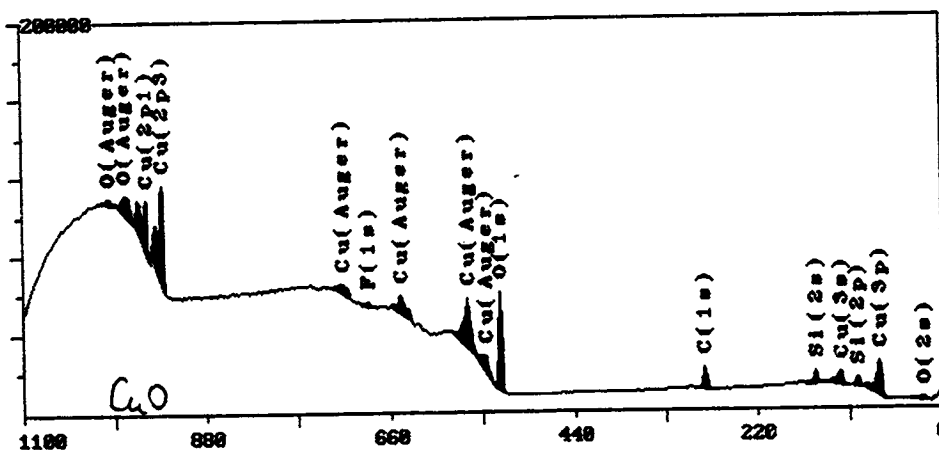
Surface Composition Table Summary

File name: CUSTRP02.MRS
 Region: 1
 Description: LDEF - ORIGINAL CU STRIP
 Operator: M D JOHNSON
 Date: Mon May 18 08:50:57 1992

Element	Binding Energy	atom %
Cu (2p3)	934.31	1.39 %
O (1s)	532.17	19.65 %
C (1s)	285.00	67.08 %
Cl (2p)	198.91	0.76 %
Si (2s)	152.75	11.12 %
Total Percent		100.00 %

Figure D-1 Survey ESCA spectrum for copper ground control specimen.

Wed Jul 14 13:01:24 M-Probe ESCA Console User ID: JESSE
 A10_01.MRS Wed Jun 23 16:13:58 1993 Operator: Jesse Cherian
 LDEF - Copper Strip A10:Darkest Region, Cut 1(0.5")
 Spot: 488x1088p Resolution: 4 Energy:
 Scans: 28 of 28 Neutralizer: 0.1eV Counts:
 Region: 1/ 1 Aperture: None



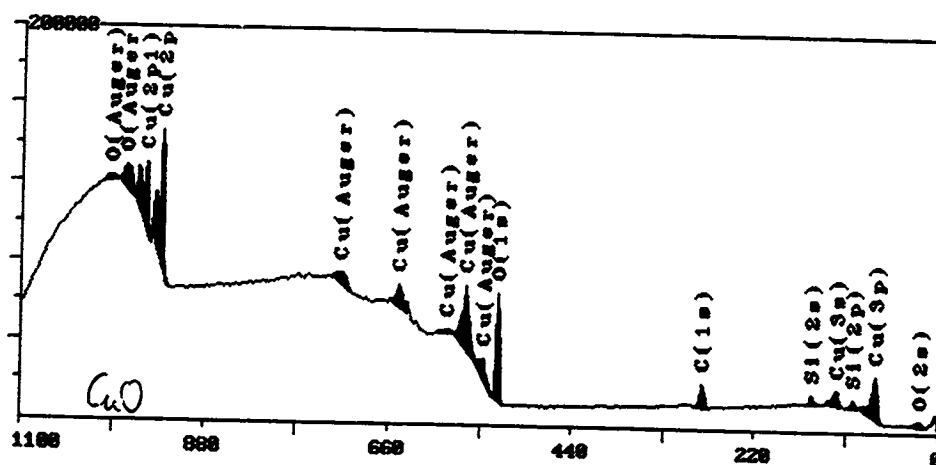
Surface Composition Table Summary

File name: A10_01.MRS
 Region: 1
 Description: LDEF - Copper Strip A10:Darkest Region, Cut 1
 Operator: Jesse Cherian
 Date: Wed Jun 23 16:13 1993

Element	Binding Energy	atom %
Cu (2p3)	934.8	16.82
F (1s)	689.8	0.68
O (1s)	531.2	48.98
C (1s)	284.6	23.81
Si (2p)	101.6	9.70

Figure D-2 Survey ESCA spectrum for tray A10 copper strap, 0.5" from shielded area.

Thu Jul 01 10:45:04 M-Probe ESCA Console User ID: JESSE
 A10_57.MRS Thu Jul 01 10:13:45 1993 Operator: Jesse Cherian
 LDEF - Copper Strip, 0.57" from edge
 Spot: 400x1000p Resolution: 4 Energy:
 Scans: 25 of 25 Neutralizer: 0.1eV Counts:
 Region: 1/ 1 Aperture: None



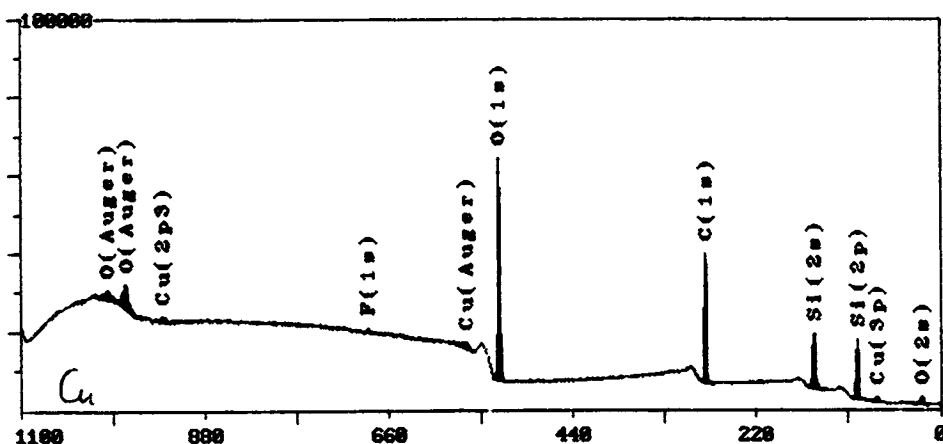
Surface Composition Table Summary

File name: A10_57.MRS
 Region: 1
 Description: LDEF - Copper Strip, 0.57" from edge
 Operator: Jesse Cherian
 Date: Thu Jul 1 10:13 1993

Element	Binding Energy	atom %
Cu (2p3)	934.6	21.41
O (1s)	531.0	49.07
C (1s)	284.6	22.65
Si (2p)	101.6	6.87

Figure D-3 Survey ESCA spectrum for tray A10 copper Strap, 0.57" from shielded area.

Wed Jul 07 07:58:52 M-Probe ESCA Console User ID: JESSE
 A10_120.MRS Thu Jul 01 14:46:14 1993 Operator: Jesse Cherian
 LDEF - Copper Strip, 1.20" from edge
 Spot: 400x1000µ Resolution: 4 Energy:
 Scans: 25 of 25 Neutralizer: 0.1eV Counts:
 Region: 1/ 1 Aperture: None



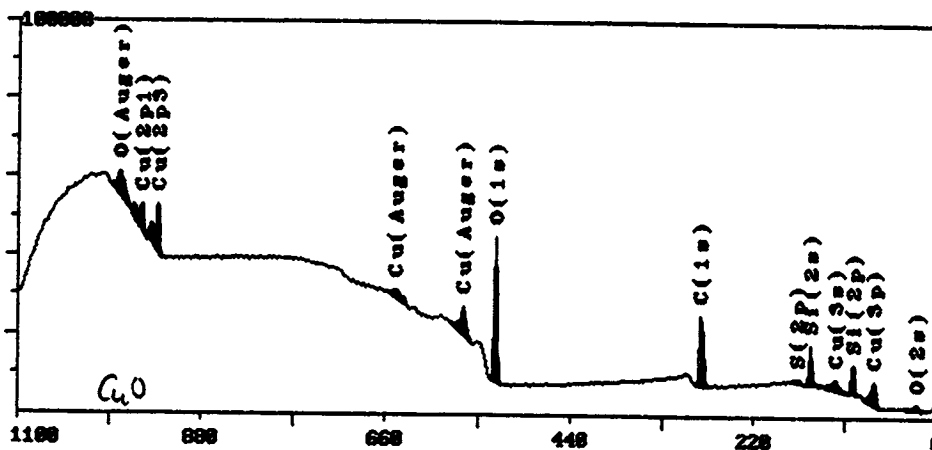
Surface Composition Table Summary

File name: A10_120.MRS
 Region: 1
 Description: LDEF - Copper Strip, 1.20" from edge
 Operator: Jesse Cherian
 Date: Thu Jul 1 14:46 1993

Element	Binding Energy	atom %
Cu (2p3/2)	936.1	0.91
F (1s)	689.0	0.45
O (1s)	532.5	33.12
C (1s)	284.6	42.63
Si (2p)	102.3	22.89

Figure D-4 Survey ESCA spectrum for tray A10 copper Strap, 1.20" from shielded area.

Thu Jun 24 12:32:00 M-Probe ESCA Console User ID: JESSE
 A10_04.MRS Thu Jun 24 12:28:27 1993 Operator: Jesse Cherian
 LDEF - Copper Strip A10: Bronze Area 4 (1.4")
 Spot: 400x1000µ Resolution: 4 Energy:
 Scans: 28 of 28 Neutralizer: 0.1eV Counts:
 Region: 1/ 1 Aperture: None



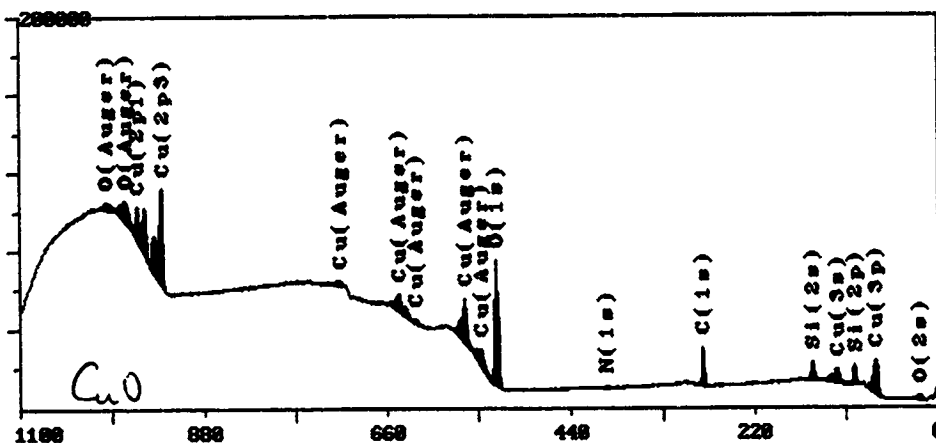
Surface Composition Table Summary

File name: A10_04.MRS
 Region: 1
 Description: LDEF - Copper Strip A10: Bronze Area 4
 Operator: Jesse Cherian
 Date: Thu Jun 24 12:28 1993

Element	Binding Energy	atom %
Cu (2p3)	935.0	4.13
O (1s)	531.8	36.31
C (1s)	284.6	40.16
S (2p)	169.0	1.55
Si (2p)	101.5	17.84

Figure D-5 Survey ESCA spectrum for tray A10 copper Strap, 1.40"
 from shielded area.

Mon Jul 12 12:23:14 N-Probe ESCA Console User ID: JESSE
 A10_250.MRS Wed Jul 07 13:43:49 1993 Operator: Jesse Cherian
 LDEF - Copper Strip A10, 2.50" from edge
 Spot: 400x1000µ Resolution: 4 Energy:
 Scans: 25 of 25 Neutralizer: 8.1eV Counts:
 Region: 1/ 1 Aperture: None



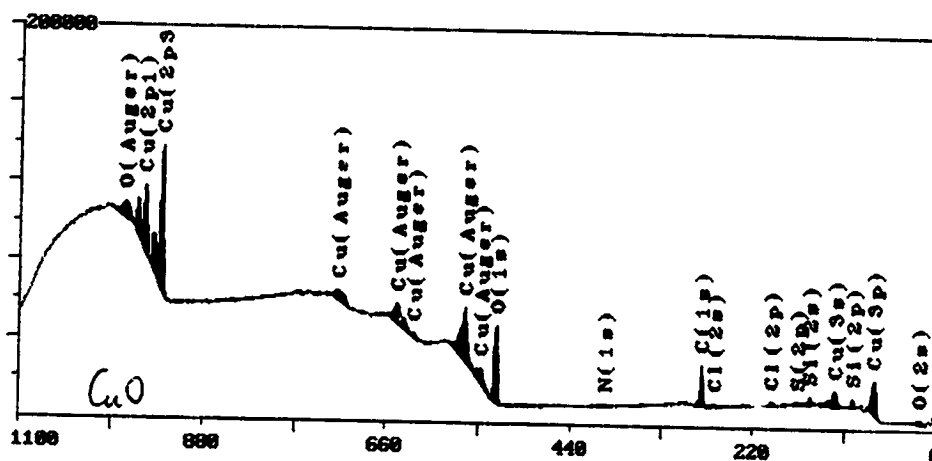
Surface Composition Table Summary

File name: A10_250.MRS
 Region: 1
 Description: LDEF - Copper Strip A10, 2.50" from edge
 Operator: Jesse Cherian
 Date: Wed Jul 7 13:43 1993

Element	Binding Energy	atom %
O (1s)	532.1	37.83
N (1s)	399.8	0.55
C (1s)	284.6	19.39
Si (2p)	102.4	10.46
Cu (2p3)	934.2	31.77

Figure D-6 Survey ESCA spectrum for tray A10 copper Strap, 2.50"
 from shielded area.

Mon Jul 12 12:18:39 M-Probe ESCA Console User ID: JESSE
 A10_275.MRS Thu Jul 08 12:14:06 1993 Operator: Jesse Cherian
 LDEF - Copper Strip A10, 2.75" from edge
 Spot: 400x1000µ Resolution: 4 Energy:
 Scans: 25 of 25 Neutralizer: 0.1eV Counts:
 Region: 1/ 1 Aperture: None



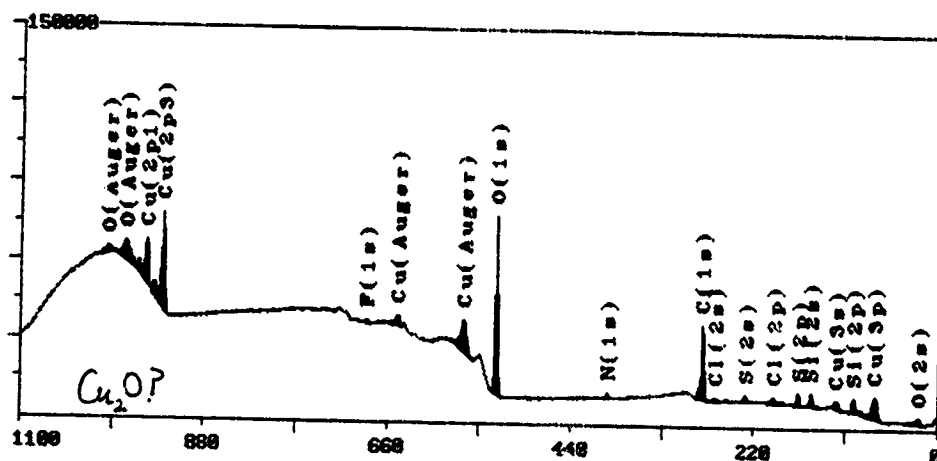
Surface Composition Table Summary

File name: A10_275.MRS
 Region: 1
 Description: LDEF - Copper Strip A10, 2.75" from edge
 Operator: Jesse Cherian
 Date: Thu Jul 8 12:14 1993

Element	Binding Energy	atom %
O (1s)	530.1	27.17
N (1s)	399.1	0.89
C (1s)	284.6	22.72
Cl (2p)	199.0	1.01
S (2p)	168.4	0.62
Si (2p)	101.9	4.20
Cu (2p3)	933.6	43.40

Figure D-7 Survey ESCA spectrum for tray A10 copper Strap, 2.75" from shielded area.

Tue Jul 13 14:02:01 M-Probe ESCA Console User ID: JESSE
 A10_400.MRS Tue Jul 13 08:29:07 1993 Operator: Jesse Cherian
 LDEF - Copper Strip A10, 4.00" from edge
 Spot: 400x1000µ Resolution: 4 Energy:
 Scans: 25 of 25 Neutralizer: 0.1eV Counts:
 Region: 1/ 1 Aperture: None



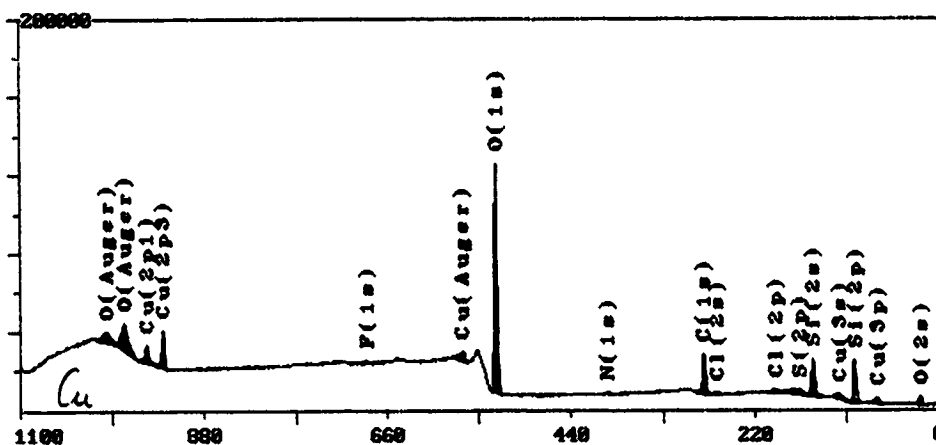
Surface Composition Table Summary

File name: A10_400.MRS
 Region: 1
 Description: LDEF - Copper Strip A10, 4.00" from edge
 Operator: Jesse Cherian
 Date: Tue Jul 13 08:29 1993

Element	Binding Energy	atom %
F (1s)	688.3	0.54
O (1s)	532.0	31.14
N (1s)	399.3	1.02
C (1s)	284.6	34.22
Cl (2p)	198.9	1.55
S (2p)	168.8	3.07
Si (2p)	102.1	8.51
Cu (2p)	933.5	19.95

Figure D-8 Survey ESCA spectrum for tray A10 copper strap, 4.00"
 from shielded area.

Tue Jul 13 15:58:28 M-Probe ESCA Console User ID: JESSE
 A10_500.MRS Tue Jul 13 15:33:18 1993 Operator: Jesse Cherian
 LDEF - Copper Strip A10, 5.00" from edge
 Spot: 400x1000µ Resolution: 4 Energy:
 Scans: 25 of 25 Neutralizer: 0.1eV Counts:
 Region: 1/ 1 Aperture: None

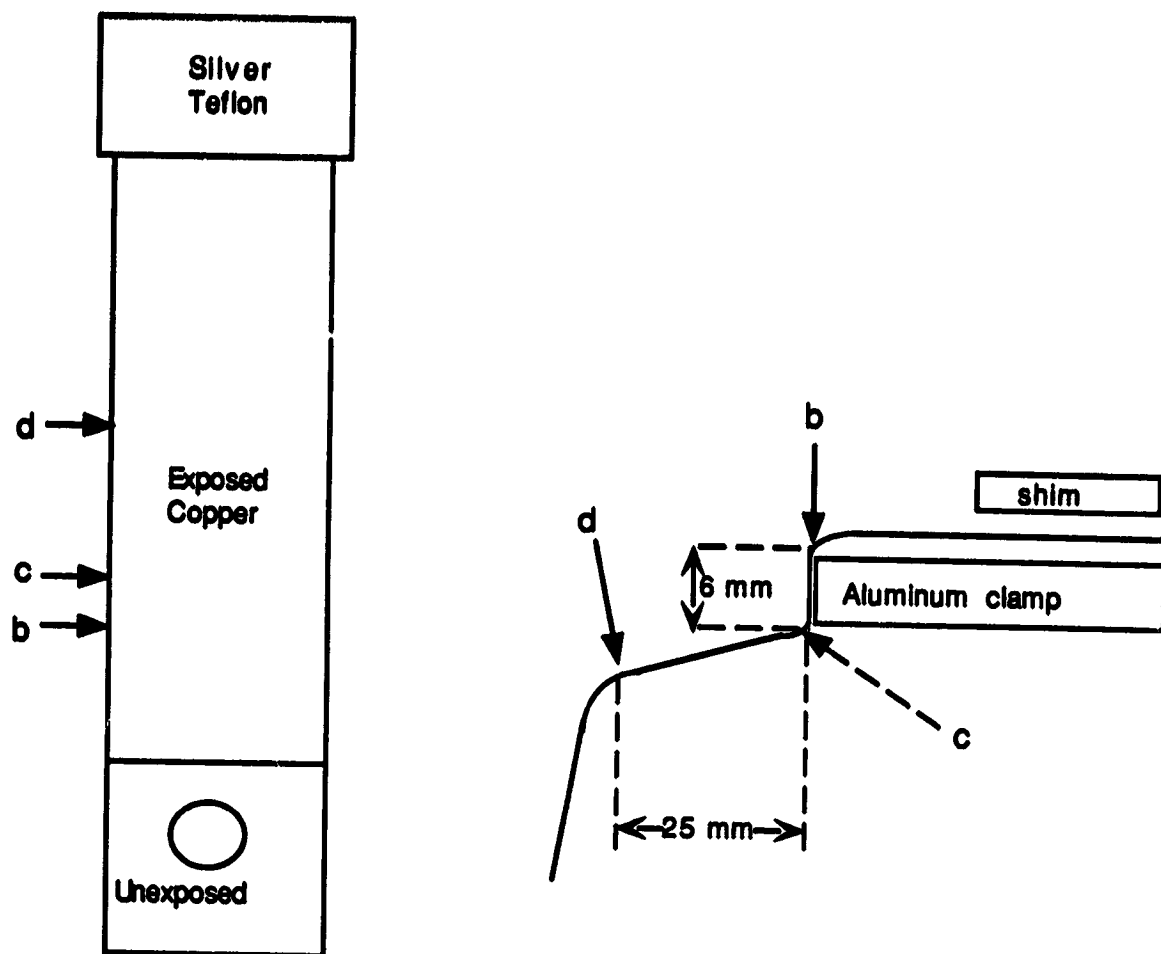


Surface Composition Table Summary

File name: A10_500.MRS
 Region: 1
 Description: LDEF - Copper Strip A10, 5.00" from edge
 Operator: Jesse Cherian
 Date: Tue Jul 13 15:33 1993

Element	Binding Energy	atom %
Cu (2p)	933.1	2.46
F (1s)	688.9	0.43
O (1s)	532.7	48.45
N (1s)	400.6	0.83
C (1s)	284.6	21.67
S (2p)	169.6	5.00
Si (2p)	103.1	21.16

Figure D-9 Survey ESCA spectrum for tray A10 copper strap, 5.00" from shielded area.

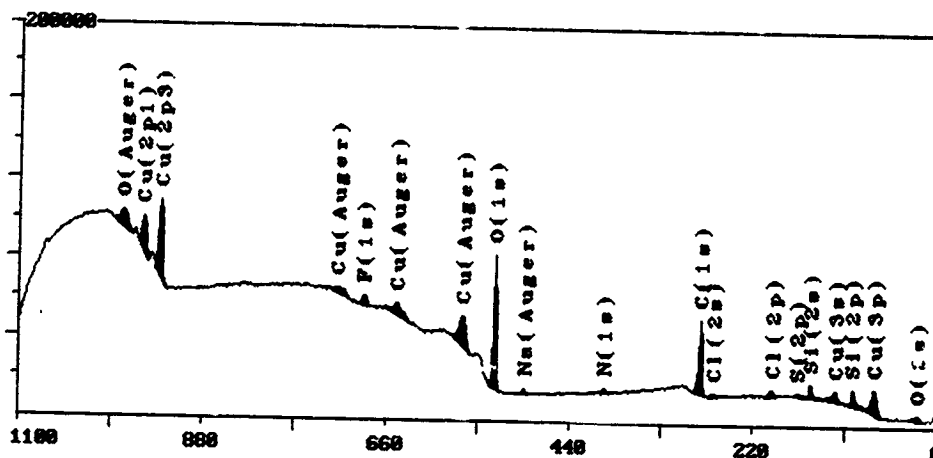


Distances are positive with increasing distance from unexposed area.

Figure D-10 Diagram of measurement locations on copper strap from tray A2.

Thu Apr 29 07:37:03 M-Probe ESCA Console
 A02_04.MRS Mon Apr 26 11:41:25 1993
 A02 - LDEF - COPPER STRAP - CLAMP AREA(4)- b-3.5mm
 Spot: 400x1000µ Resolution: 4
 Scans: 20 of 20 Neutralizer: 0.0eU
 Region: 1/ 1 Aperture: None

User ID: LDEF
 Operator:
 Energy:
 Counts:



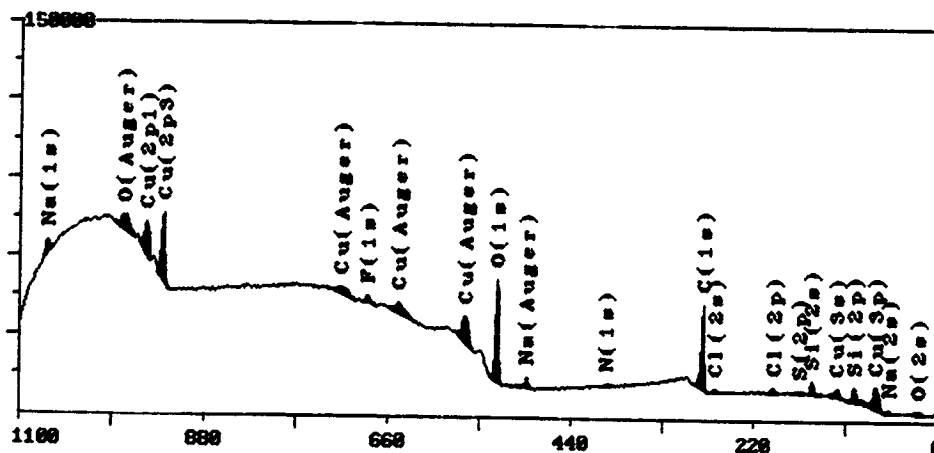
Surface Composition Table Summary

File name: A02_04.MRS
 Region: 1
 Description: A02 - LDEF - COPPER STRAP - CLAMP AREA(4)-
 b-3.5mm
 Operator:
 Date: Mon Apr 26 11:41 1993

Element	Binding Energy	atom %
Cu (2p3)	933.6	6.43
F (1s)	688.5	2.26
O (1s)	531.9	30.30
Na (Auger)	496.5	0.96
N (1s)	399.6	0.99
C (1s)	284.6	44.02
Cl (2p)	198.7	1.52
S (2p)	168.4	0.76
Si (2p)	102.1	12.76

Figure D-11 Survey ESCA spectrum for tray A2 copper strap at location b-3.5mm.

Thu Apr 29 07:38:12 M-Probe ESCA Console User ID: LDEF
 A02_05.MRS Mon Apr 26 13:24:54 1993 Operator:
 A02 - LDEF - COPPER STRAP - (5) - c-6mm
 Spot: 400x1000µ Resolution: 4 Energy:
 Scans: 28 of 28 Neutralizer: 8.0eV Counts:
 Region: 1/ 1 Aperture: None



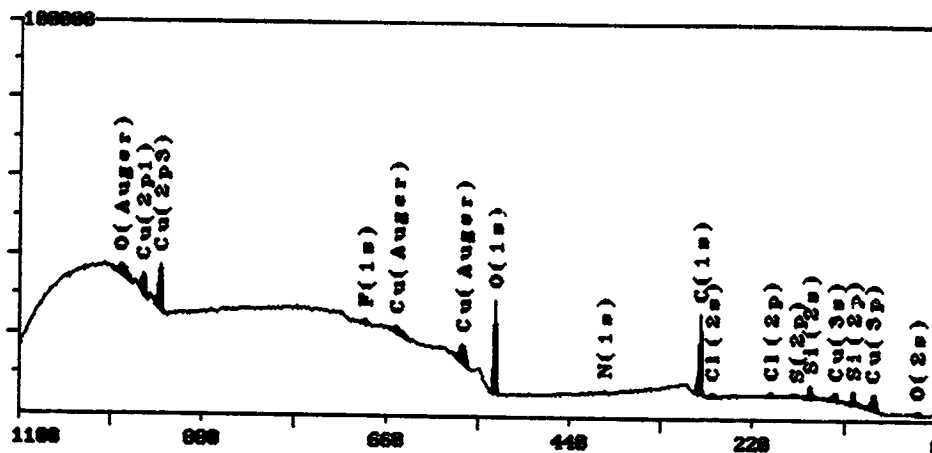
Surface Composition Table Summary

File name: A02_05.MRS
 Region: 1
 Description: A02 - LDEF - COPPER STRAP - (5) - c-6mm
 Operator:
 Date: Mon Apr 26 13:24 1993

Element	Binding Energy	atom %
Na (1s)	1071.2	10.56
Cu (2p3)	933.4	5.52
F (1s)	688.8	1.32
O (1s)	532.4	23.91
N (1s)	399.9	0.59
C (1s)	284.6	46.46
Cl (2p)	199.2	1.22
S (2p)	168.9	0.74
Si (2p)	102.1	9.68

Figure D-12 Survey ESCA spectrum for tray A2 copper strap at location c-6.mm.

Thu Apr 29 07:39:21 M-Probe ESCA Console User ID: LDEF
 A02_06.MRS Mon Apr 26 14:38:18 1993 Operator:
 A02 - LDEF - COPPER STRAP - (6) - c-1mm
 Spot: 400x1000µ Resolution: 4 Energy:
 Scans: 28 of 28 Neutralizer: 0.8eV Counts:
 Region: 1/ 1 Aperture: None



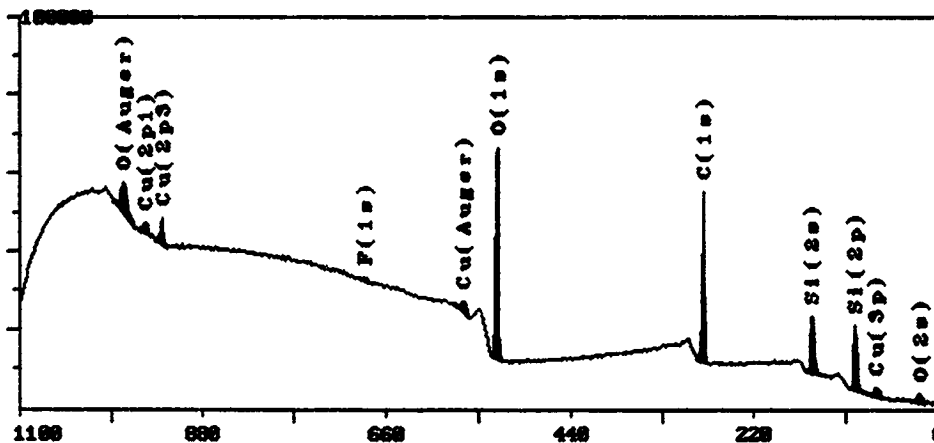
Surface Composition Table Summary

File name: A02_06.MRS
 Region: 1
 Description: A02 - LDEF - COPPER STRAP - (6) - c-1mm
 Operator:
 Date: Mon Apr 26 14:38 1993

Element	Binding Energy	atom %
Cu (2p3)	933.6	4.23
F (1s)	688.3	1.20
O (1s)	531.9	24.79
N (1s)	399.5	1.08
C (1s)	284.6	53.76
Cl (2p)	198.9	1.14
S (2p)	158.5	0.80
Si (2p)	101.6	13.00

Figure D-13 Survey ESCA spectrum for tray A2 copper strap at
 location c-1.mm.

Thu Apr 29 07:43:11 M-Probe ESCA Console User ID: LDEF
 A02_08.MRS Tue Apr 27 09:11:54 1993 Operator:
 A02 - LDEF - COPPER STRAP - TRAY AREA (8) - d-13mm
 Spot: 400x1000µ Resolution: 4 Energy:
 Scans: 20 of 20 Neutralizer: 0.0eV Counts:
 Region: 1/ 1 Aperture: None



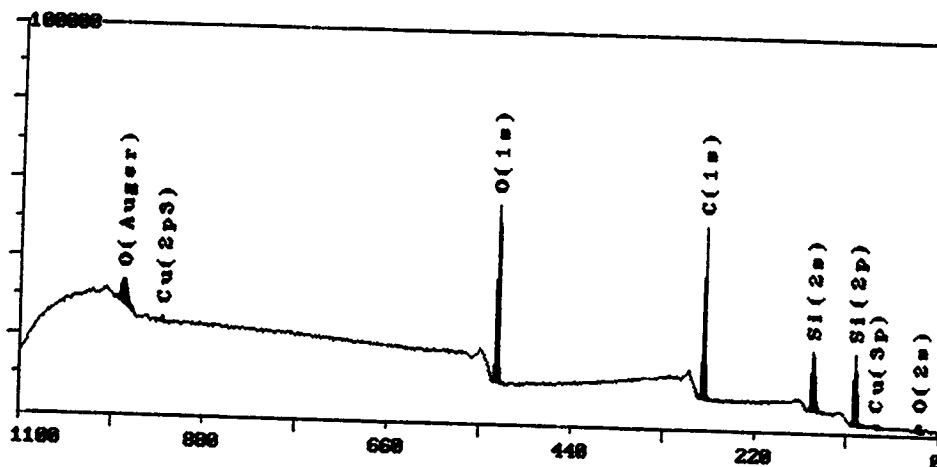
Surface Composition Table Summary

File name: A02_08.MRS
 Region: 1
 Description: A02 - LDEF - COPPER STRAP - TRAY AREA (8) - d-13mm
 Operator:
 Date: Tue Apr 27 09:11 1993

Element	Binding Energy	atom %
Cu (2p3)	933.4	1.12
F (1s)	689.0	0.58
O (1s)	532.4	30.59
C (1s)	284.6	46.44
Si (2p)	102.1	21.27

Figure D-14 Survey ESCA spectrum for tray A2 copper strap at location d-13mm.

Thu Apr 29 07:41:24 M-Probe ESCA Console User ID: LDEF
 A02_07.MRS Tue Apr 27 08:14:28 1993 Operator:
 A02 - LDEF - COPPER STRAP - TRAY AREA (7) - d-12mm
 Spot: 488x1000µ Resolution: 4 Energy:
 Scans: 20 of 20 Neutralizer: 0.0eV Counts:
 Region: 1/ 1 Aperture: None



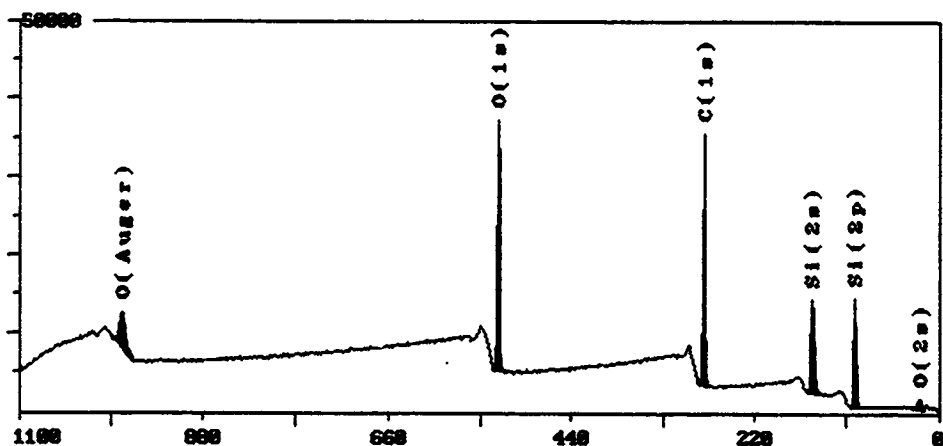
Surface Composition Table Summary

File name: A02_07.MRS
 Region: 1
 Description: A02 - LDEF - COPPER STRAP - TRAY AREA (7) - d-12mm
 Operator:
 Date: Tue Apr 27 08:14 1993

Element	Binding Energy	atom %
Cu (2p3)	933.3	0.47
O (1s)	532.7	26.33
C (1s)	284.6	52.19
Si (2p)	102.1	21.01

Figure D-15 Survey ESCA spectrum for tray A2 copper strap at location d-12mm.

Thu Apr 29 07:44:07 M-Probe ESCA Console User ID: LDEF
 A02_09.MRS Wed Apr 28 10:37:37 1993 Operator:
 A02 - LDEF - COPPER STRAP - TRAY AREA (9) - d-5mm
 Spot: 100x1000µ Resolution: 4 Energy:
 Scans: 20 of 20 Neutralizer: 0.0eU Counts:
 Region: 1/ 1 Aperture: None

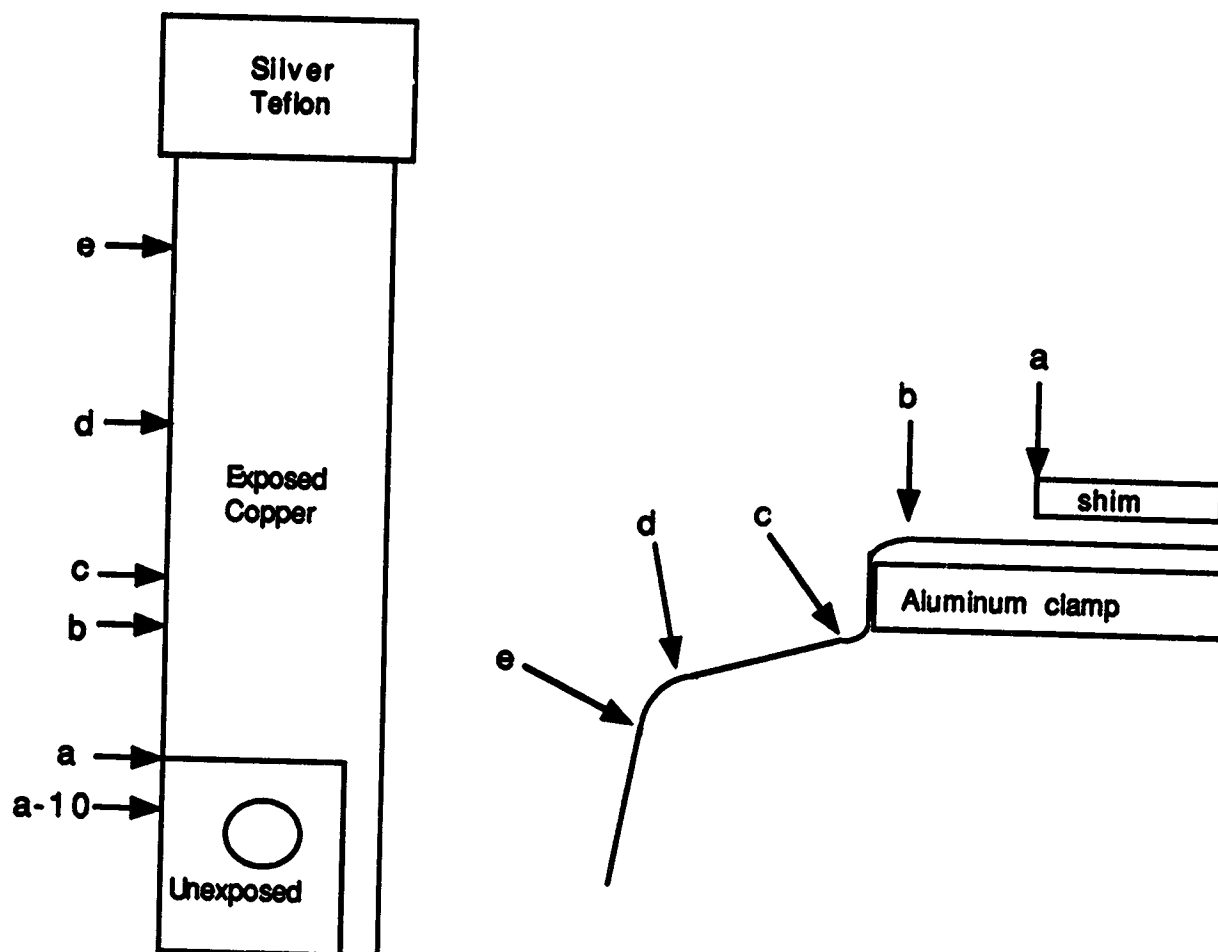


Surface Composition Table Summary

File name: A02_09.MRS
 Region: 1
 Description: A02 - LDEF - COPPER STRAP - TRAY AREA (9) -
 d-5mm
 Operator:
 Date: Wed Apr 28 10:37 1993

Element	Binding Energy	atom %
O (1s)	532.7	25.66
C (1s)	284.6	52.32
Si (2p)	102.1	22.02

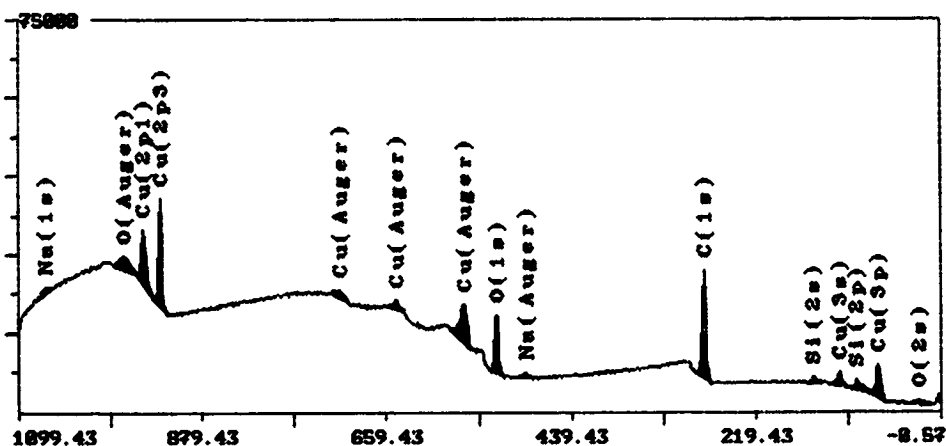
Figure D-16 Survey ESCA spectrum for tray A2 copper strap at
 location d-5.mm.



Distances are positive with increasing distance from unexposed area.
 Approximate distances between letter markers are as follows;
 a-->b 25mm, b-->c 13mm, c-->d 25mm, d-->e 16mm.

Figure D-17. Diagram of measurement locations on copper strap from tray D11.

Thu Apr 30 18:03:34 M-Probe ESCA Console User ID: MELISSA
 D11_05.MRS Fri Apr 10 16:47:14 1992 Operator: MDJ
 D11 COPPER STRIP (a-10mm)
 Spot: 400x1000µ Resolution: 4 Energy:
 Scans: 28 of 28 Neutralizer: 3.0eU Counts:
 Region: 1/ 8 Aperture: None



Surface Composition Table Summary

File name: D11_05.MRS
 Region: 1
 Description: D11 COPPER STRIP (a-10mm)
 Operator: MDJ
 Date: Fri Apr 10 16:47:14 1992

Element	Binding Energy	atom %
Cu (2p3)	933.60	6.79 %
O (1s)	532.37	16.16 %
Na (Auger)	496.84	1.74 %
C (1s)	285.00	63.03 %
Si (2p)	102.33	12.28 %
Total Percent		100.00 %

Figure D-18 Survey ESCA spectrum for tray D11 copper strap at location a-10.mm.

Thu Apr 30 14:31:48
D1101.MRS

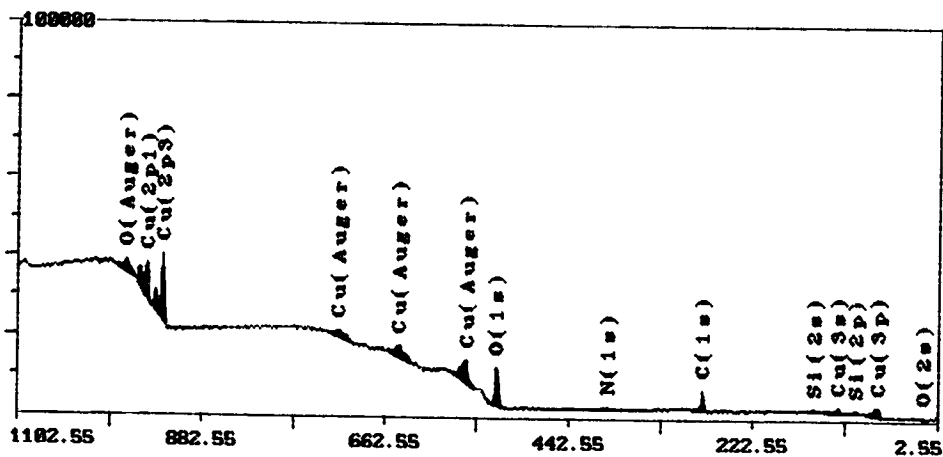
M Probe ESCA Console
Mon Apr 27 21:26:59 1992

User ID: MELISSA
Operator: M D JOHNSON

a+10mm
Spot: 400x1000µ
Scans: 20 of 20
Region: 1/ 8

Resolution: 4
Neutralizer: 3.0eV
Aperture: None

Energy:
Counts:



Surface Composition Table Summary

File name: D1101.MRS
Region: 1
Description: a+10mm

Operator: M D JOHNSON
Date: Mon Apr 27 21:26:59 1992

Element	Binding Energy	atom %
O (1s)	531.48	36.73 %
N (1s)	399.79	1.65 %
C (1s)	285.00	31.26 %
Si (2p)	102.29	3.61 %
Cu (2p1)	954.28	26.76 %
Total Percent		100.00 %

Figure D-19 Survey ESCA spectrum for tray D11 copper strap at location a+10.mm.

Thu Apr 30 14:39:45

M-Probe ESCA Console

User ID: MELISSA

D1102.MRS

Tue Apr 28 00:43:51 1992

Operator: M D JOHNSON

a+22mm

Spot: 488x1888µ

Resolution: 4

Energy:

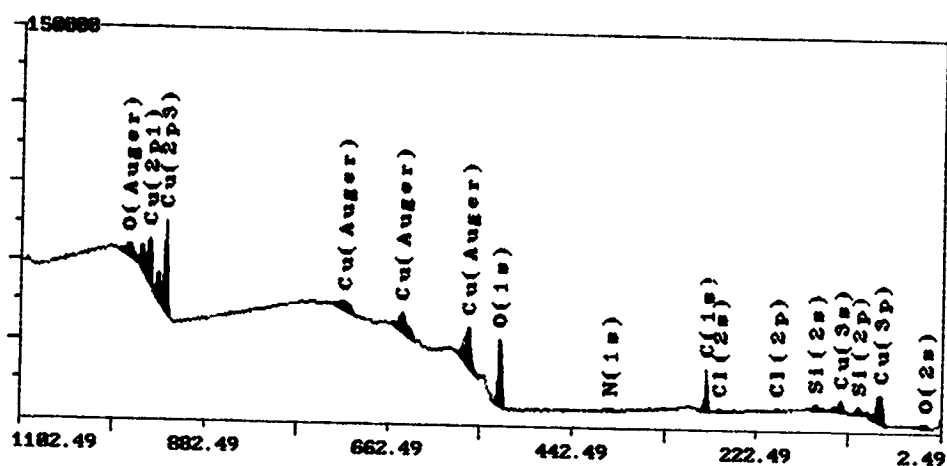
Scans: 28 of 28

Neutralizer: 3.8eU

Counts:

Region: 1/ 8

Aperture: None



Surface Composition Table Summary

File name: D1102.MRS

Region: 1

Description: a+22mm

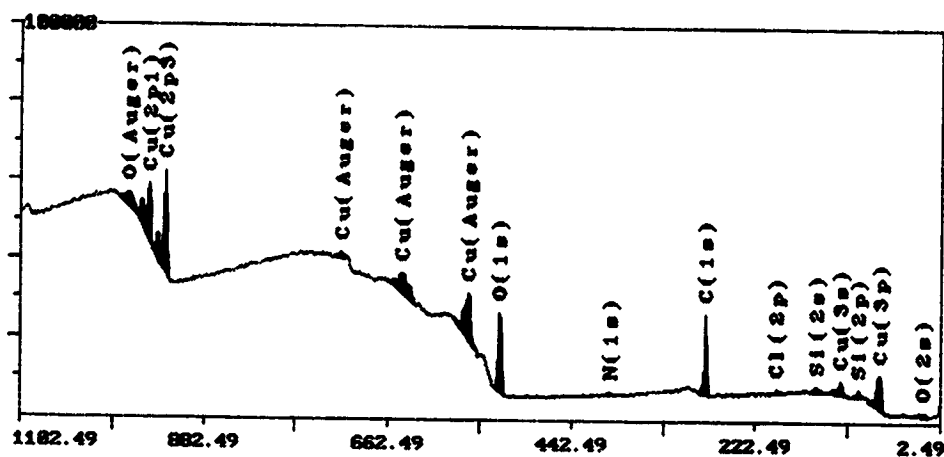
Operator: M D JOHNSON

Date: Tue Apr 28 00:43:51 1992

Element	Binding Energy	atom %
O (1s)	531.37	35.40 %
N (1s)	400.42	1.02 %
C (1s)	285.00	36.25 %
Cl (2p)	198.99	0.93 %
Si (2p)	102.43	8.76 %
Cu (2p3)	935.13	17.64 %
Total Percent		100.00 %

Figure D-20 Survey ESCA spectrum for tray D11 copper strap at location a+22.mm.

Thu Apr 30 15:15:55 M-Probe ESCA Console User ID: MELISSA
D1103.MRS Tue Apr 28 04:00:41 1992 Operator: M D JOHNSON
b
Spot: 480x1000µ Resolution: 4 Energy:
Scans: 20 of 20 Neutralizer: 3.0eU Counts:
Region: 1/ 8 Aperture: None



Surface Composition Table Summary

File name: D1103.MRS
Region: 1
Description: b
Operator: M D JOHNSON
Date: Tue Apr 28 04:00:41 1992

Element	Binding Energy	atom %
O (1s)	531.52	29.93 %
N (1s)	399.51	1.19 %
C (1s)	285.00	48.40 %
Cl (2p)	199.15	1.11 %
Si (2p)	102.40	6.05 %
Cu (2p3)	935.13	13.31 %
Total Percent		100.00 %

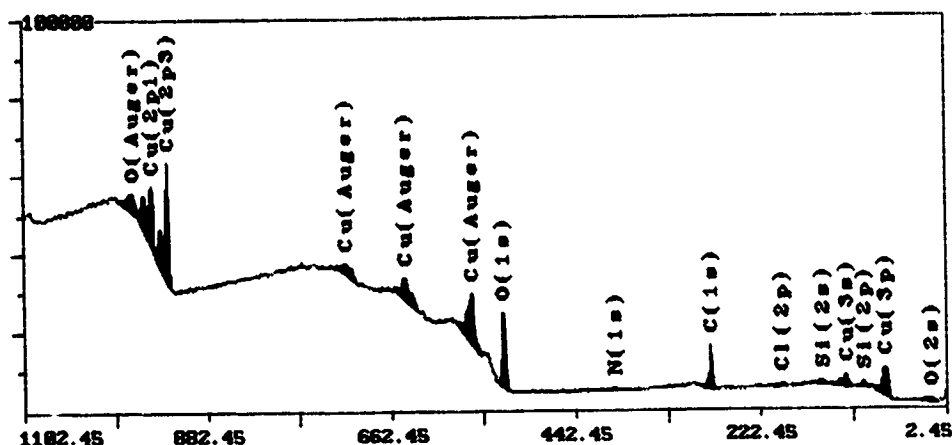
Figure D-21 Survey ESCA spectrum for tray D11 copper strap at location b.

Thu Apr 30 15:28:37
D1104.MRS
b+2mm
Spot: 488x1000µ
Scans: 28 of 28
Region: 1/ 8

M-Probe ESCA Console
Tue Apr 28 07:17:38 1992
Resolution: 4
Neutralizer: 3.0eV
Aperture: None

User ID: MELISSA
Operator: M D JOHNSON

Energy:
Counts:



Surface Composition Table Summary

File name: D1104.MRS
Region: 1
Description: b+2mm

Operator: M D JOHNSON
Date: Tue Apr 28 07:17:30 1992

Element	Binding Energy	atom %
O (1s)	531.23	36.71 %
N (1s)	399.66	1.33 %
C (1s)	285.00	35.66 %
Cl (2p)	199.18	1.15 %
Si (2s)	152.89	4.62 %
Cu (2p3)	935.09	20.53 %
Total Percent		100.00 %

Figure D-22 Survey ESCA spectrum for tray D11 copper strap at location b+2.mm.

Thu Apr 30 15:24:37

D11_001.MRS

b+4mm

Spot: 400x1000µ

Scans: 20 of 20

Region: 1/ 3

M-Probe ESCA Console

Thu Apr 30 10:05:36 1992

Resolution: 4

Neutralizer: 3.8eU

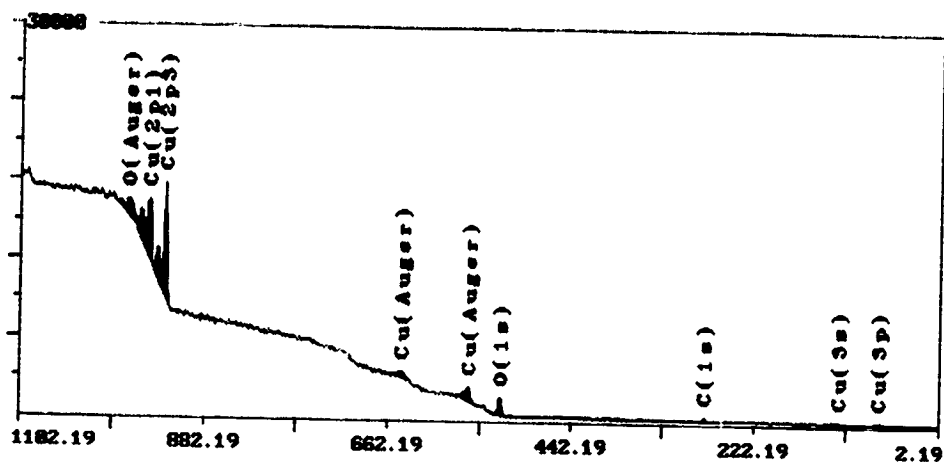
Aperture: None

User ID: MELISSA

Operator: M D JOHNSON

Energy:

Counts:



Surface Composition Table Summary

File name: D11_001.MRS

Region: 1

Description: b+4mm

Operator: M D JOHNSON

Date: Thu Apr 30 10:05:36 1992

Element	Binding Energy	atom %
O (1s)	530.86	25.60 %
C (1s)	284.90	7.92 %
Cu (3p)	76.13	3.12 %
Cu (2p3)	934.83	63.35 %
Total Percent		100.00 %

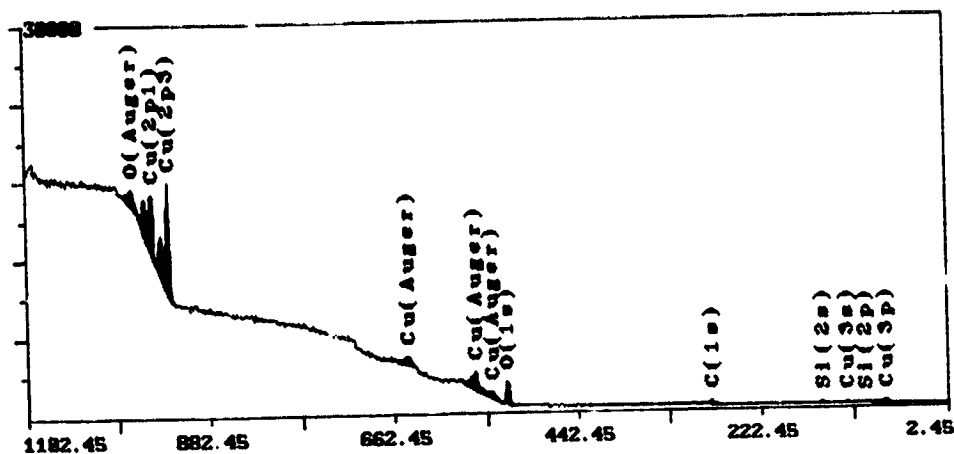
Figure D-23 Survey ESCA spectrum for tray D11 copper strap at location b+4mm.

Thu Apr 30 10:47:41
 D11_002.MRS
 b+6mm
 Spot: 400x1000µ
 Scans: 28 of 28
 Region: 1/ 3

M-Probe ESCA Console
 Thu Apr 30 11:27:28 1992
 Resolution: 4
 Neutralizer: 3.0eU
 Aperture: None

User ID: MELISSA
 Operator: M D JOHNSON

Energy:
 Counts:



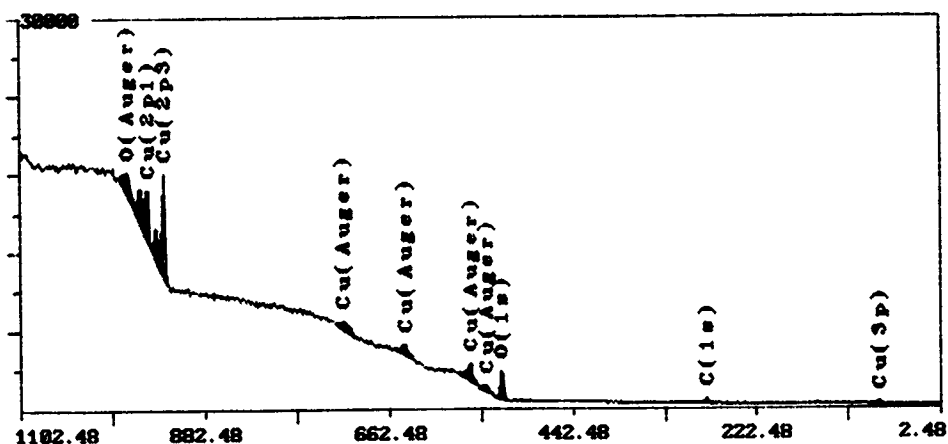
Surface Composition Table Summary

File name: D11_002.MRS
 Region: 1
 Description: b+6mm
 Operator: M D JOHNSON
 Date: Thu Apr 30 11:27:28 1992

Element	Binding Energy	atom %
O (1s)	531.45	28.96 %
C (1s)	285.00	10.49 %
Si (2s)	152.83	3.22 %
Cu (3p)	77.35	3.99 %
Cu (2p3)	935.09	53.33 %
Total Percent		100.00 %

Figure D-24 Survey ESCA spectrum for tray D11 copper strap at location b+6mm.

Thu Apr 30 15:51:27 M-Probe ESCA Console User ID: MELISSA
 D11_003.MRS Thu Apr 30 12:46:52 1992 Operator: M D JOHNSON
 b+8mm
 Spot: 400x1000µ Resolution: 4 Energy:
 Scans: 28 of 28 Neutralizer: 3.0eV Counts:
 Region: 1/ 3 Aperture: None



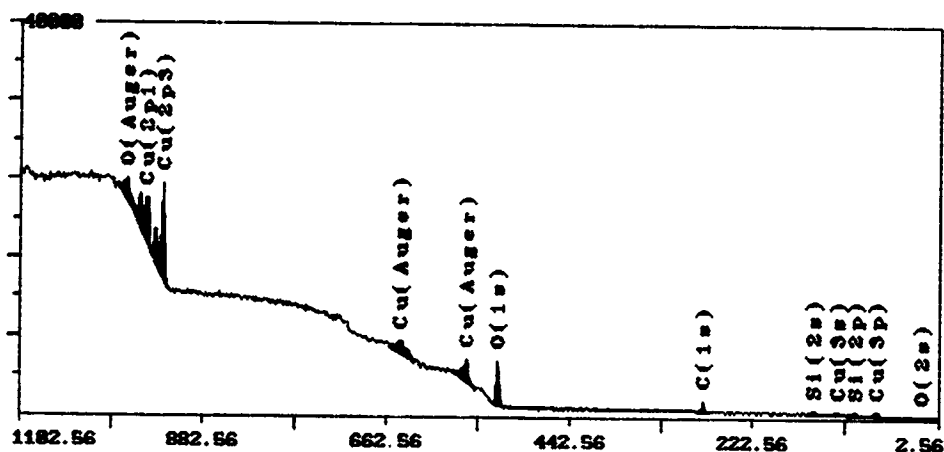
Surface Composition Table Summary

File name: D11_003.MRS
 Region: 1
 Description: b+8mm
 Operator: M D JOHNSON
 Date: Thu Apr 30 12:46:52 1992

Element	Binding Energy	atom %
O (1s)	531.76	39.33 %
C (1s)	285.00	13.22 %
Cu (2p3)	935.12	17.45 %
Total Percent		100.00 %

Figure D-25 Survey ESCA spectrum for tray D11 copper strap at location b+8.mm.

Thu Apr 30 15:56:41 M-Probe ESCA Console User ID: MELISSA
 D11_004.MRS Thu Apr 30 14:06:16 1992 Operator: M D JOHNSON
 b+10mm
 Spot: 400x1000µ Resolution: 4 Energy:
 Scans: 28 of 28 Neutralizer: 3.0eV Counts:
 Region: 1/ 3 Aperture: None



Surface Composition Table Summary

File name: D11_004.MRS
 Region: 1
 Description: b+10mm
 Operator: M D JOHNSON
 Date: Thu Apr 30 14:06:16 1992

Element	Binding Energy	atom %
Cu (2p3)	934.90	35.32 %
O (1s)	532.05	42.01 %
C (1s)	285.00	17.60 %
Si (2p)	102.36	5.07 %
Total Percent		100.00 %

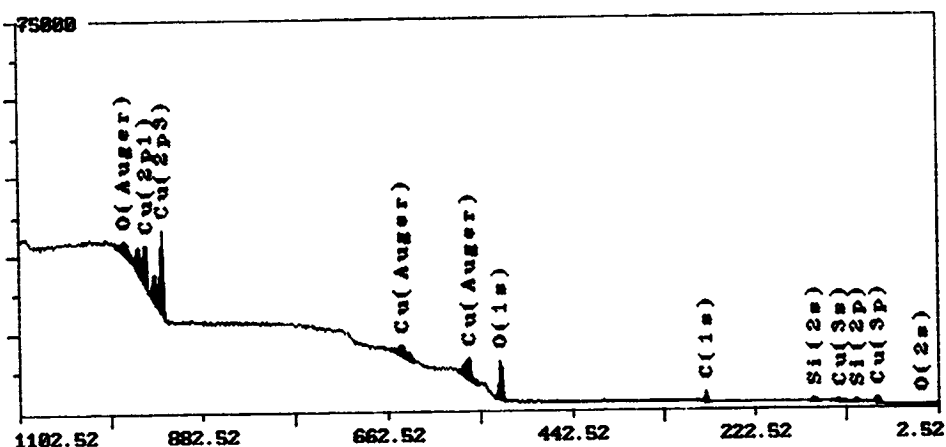
Figure D-26 Survey ESCA spectrum for tray D11 copper strap at
 location b+10.mm.

Thu Apr 30 10:04:11
D11_005.MRS
b+12mm
Spot: 400x1000µ
Scans: 20 of 20
Region: 1/ 3

M-Probe ESCA Console
Thu Apr 30 15:32:06 1992
Resolution: 4
Neutralizer: 3.0eV
Aperture: None

User ID: MELISSA
Operator: M D JOHNSON

Energy:
Counts:



Surface Composition Table Summary

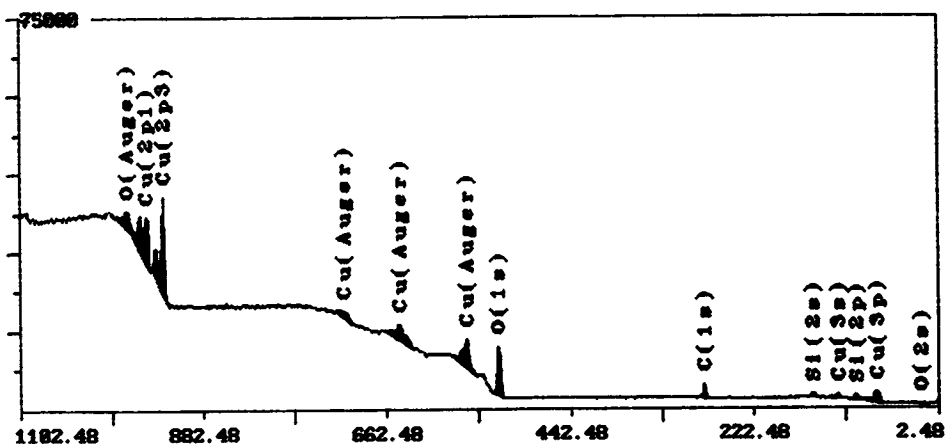
File name: D11_005.MRS
Region: 1
Description: b+12mm

Operator: M D JOHNSON
Date: Thu Apr 30 15:32:06 1992

Element	Binding Energy	atom %
O (1s)	531.77	41.95 %
C (1s)	285.00	18.59 %
Si (2s)	153.86	6.91 %
Cu (2p3)	935.16	32.55 %
Total Percent		100.00 %

Figure D-27 Survey ESCA spectrum for tray D11 copper strap at location b+12.mni.

Fri May 01 09:33:38 M-Probe ESCA Console User ID: MELISSA
 D11_006.MRS Thu Apr 30 16:55:20 1992 Operator: M D JOHNSON
 b+13mm
 Spot: 400x1000µ Resolution: 4 Energy:
 Scans: 20 of 20 Neutralizer: 3.0eU Counts:
 Region: 1/ 3 Aperture: None



Surface Composition Table Summary

File name: D11_006.MRS
 Region: 1
 Description: b+13mm
 Operator: M D JOHNSON
 Date: Thu Apr 30 16:55:20 1992

Element	Binding Energy	atom %
O (1s)	531.64	43.77 %
C (1s)	285.00	20.56 %
Si (2s)	153.57	7.82 %
Cu (2p3)	935.12	27.85 %
Total Percent		100.00 %

Figure D-28 Survey ESCA spectrum for tray D11 copper strap at location b+13.mm.

Fri May 01 09:38:23

M-Probe ESCA Console

User ID: MELISSA

D11_007.MRS

Thu Apr 30 18:14:45 1992

Operator: M D JOHNSON

c+5mm

Spot: 488x1000µ

Resolution: 4

Energy:

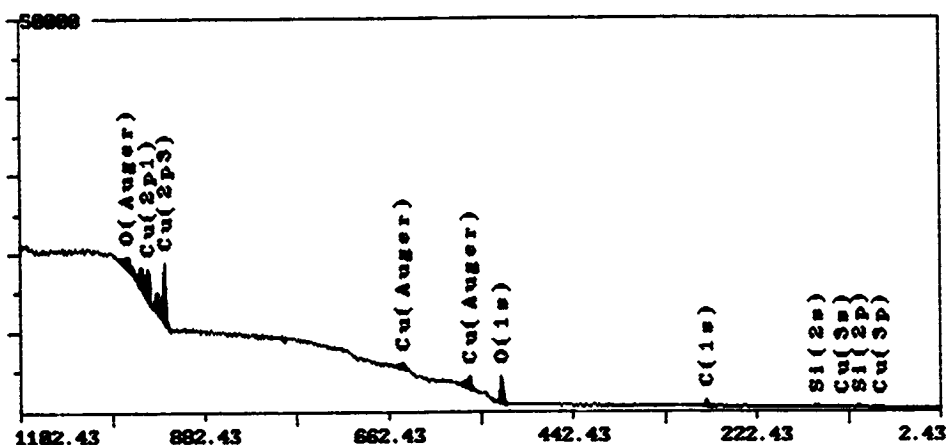
Scans: 20 of 20

Neutralizer: 3.0eV

Counts:

Region: 1/ 3

Aperture: None



Surface Composition Table Summary

File name: D11_007.MRS

Region: 1

Description: c+5mm

Operator: M D JOHNSON

Date: Thu Apr 30 18:14:45 1992

Element	Binding Energy	atom %
O (1s)	531.96	40.83 %
C (1s)	284.99	19.03 %
Si (2s)	153.31	5.21 %
Cu (2p3)	935.07	34.93 %

Total Percent 100.00 %

Figure D-29 Survey ESCA spectrum for tray D11 copper strap at location c+5.mm.

Fri May 01 09:41:26
D11_008.MRS

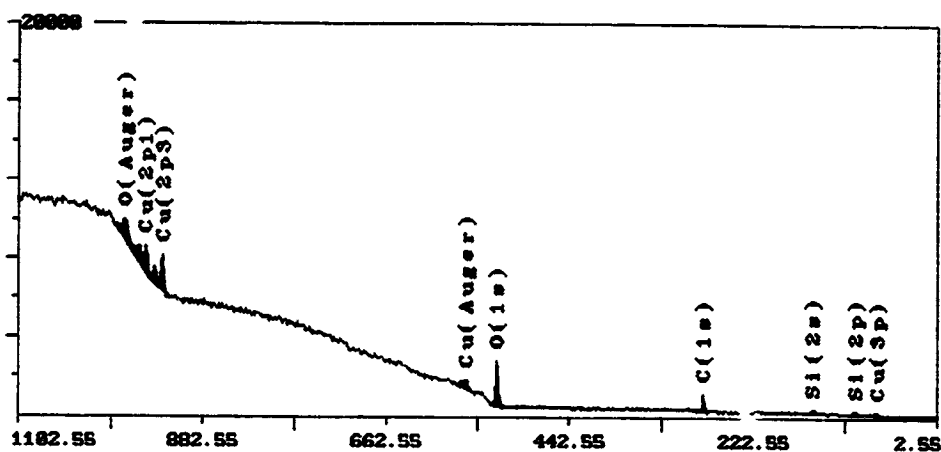
M-Probe ESCA Console
Thu Apr 30 19:34:11 1992

User ID: MELISSA
Operator: M D JOHNSON

Spot: 400x1000µ
Scans: 28 of 28
Region: 1/ 3

Resolution: 4
Neutralizer: 3.0eV
Aperture: None

Energy:
Counts:



Surface Composition Table Summary

File name: D11_008.MRS
Region: 1
Description: c+10mm
Operator: M D JOHNSON
Date: Thu Apr 30 19:34:11 1992

Element	Binding Energy	atom %
O (1s)	532.36	45.95 %
C (1s)	284.99	28.79 %
Si (2s)	153.36	9.40 %
Cu (2p3)	935.19	15.87 %
Total Percent		100.00 %

Figure D-30 Survey ESCA spectrum for tray D11 copper strap at location c+10.mm.

Wed May 20 08:05:15
D_11_01.MRS

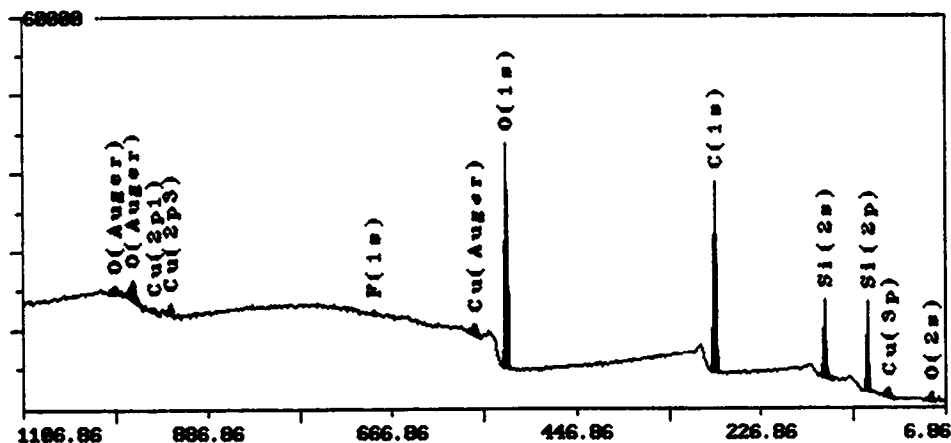
M-Probe ESCA Console
Tue May 19 18:41:59 1992

User ID: MELISSA
Operator: M D JOHNSON

Spot: 400x1000µ
Scans: 20 of 20
Region: 1/ 5

Resolution: 4
Neutralizer: 3.0eV
Aperture: None

Energy:
Counts:



Surface Composition Table Summary

File name: D_11_01.MRS
Region: 1
Description: d

Operator: M D JOHNSON
Date: Tue May 19 18:41:59 1992

Element	Binding Energy	atom %
Cu (2p3)	935.03	0.47 %
O (1s)	533.14	26.04 %
C (1s)	284.99	47.85 %
Si (2s)	153.75	25.30 %
F (1s)	691.30	0.35 %
Total Percent		100.00 %

Figure D-31 Survey ESCA spectrum for tray D11 copper strap at location d.

Wed May 28 08:11:25
D_11_02.MRS
d+2mm

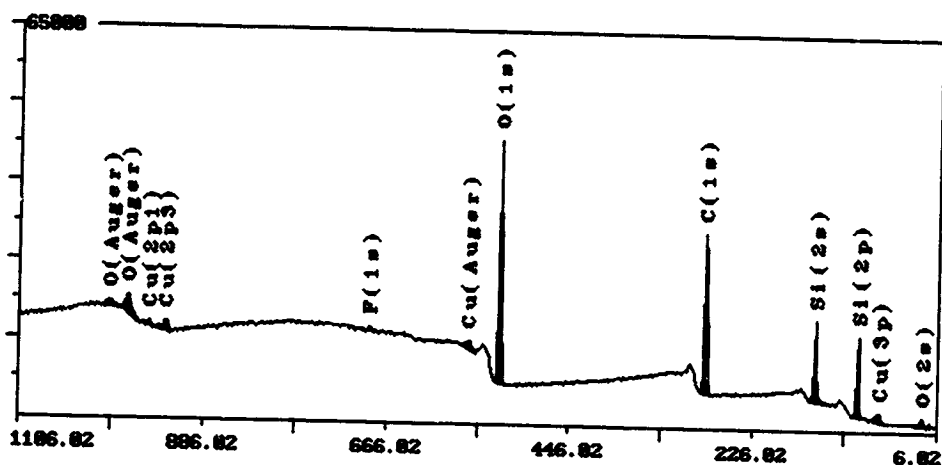
M-Probe ESCA Console
Tue May 19 21:28:31 1992

User ID: MELISSA
Operator: M D JOHNSON

Spot: 400x1000µ
Scans: 28 of 28
Region: 1/ 5

Resolution: 4
Neutralizer: 3.0eV
Aperture: None

Energy:
Counts:



Surface Composition Table Summary

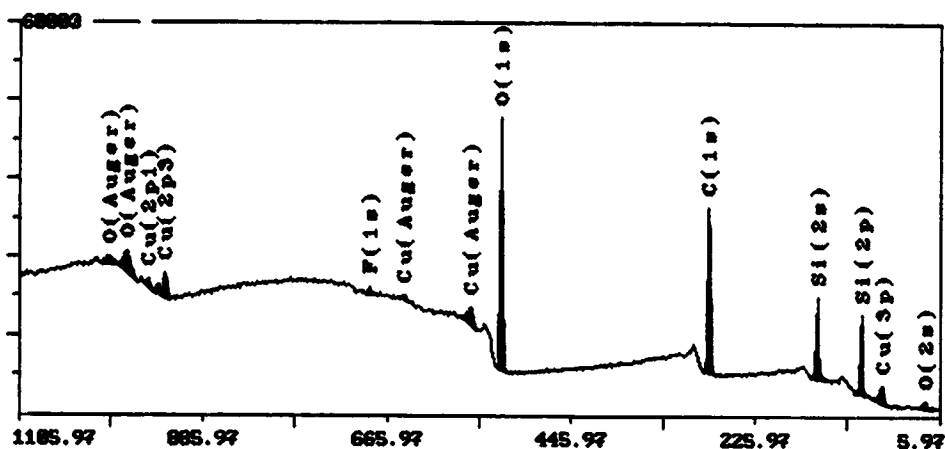
File name: D_11_02.MRS
Region: 1
Description: d+2mm

Operator: M D JOHNSON
Date: Tue May 19 21:20:31 1992

Element	Binding Energy	atom %
Cu (2p3)	935.08	0.53 %
F (1s)	691.00	0.56 %
O (1s)	532.61	25.81 %
C (1s)	285.00	48.00 %
Si (2s)	153.25	25.10 %
Total Percent		100.00 %

Figure D-32 Survey ESCA spectrum for tray D11 copper strap at location d+2.mm.

Wed May 28 09:16:04 M-Probe ESCA Console User ID: MELISSA
D_11_03.MRS Tue May 19 23:59:02 1992 Operator: M D JOHNSON
d+4mm
Spot: 400x1000µ Resolution: 4 Energy:
Scans: 20 of 20 Neutralizer: 3.0eV Counts:
Region: 1/ 5 Aperture: None



Surface Composition Table Summary

File name: D_11_03.MRS
Region: 1
Description: d+4mm
Operator: M D JOHNSON
Date: Tue May 19 23:59:02 1992

Element	Binding Energy	atom %
Cu (2p3)	935.24	1.45 %
F (1s)	691.03	0.62 %
O (1s)	532.56	26.87 %
C (1s)	285.00	46.09 %
Si (2s)	153.23	24.98 %
Total Percent		100.00 %

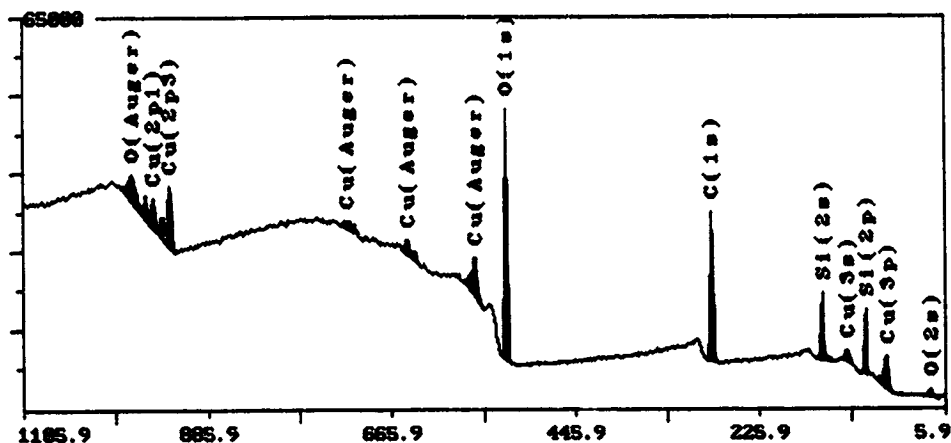
Figure D-33 Survey ESCA spectrum for tray D11 copper strap at location d+4.mm.

Wed May 20 08:21:37
D_11_04.MRS
d+6mm
Spot: 488x1000µ
Scans: 20 of 20
Region: 1/ 5

M-Probe ESCA Console
Wed May 20 02:37:32 1992
Resolution: 4
Neutralizer: 3.0eV
Aperture: None

User ID: MELISSA
Operator: M D JOHNSON

Energy:
Counts:



Surface Composition Table Summary

File name: D_11_04.MRS
Region: 1
Description: d+6mm

Operator: M D JOHNSON
Date: Wed May 20 02:37:32 1992

Element	Binding Energy	atom %
Cu (2p3)	935.13	3.05 %
O (1s)	532.43	31.26 %
C (1s)	285.00	42.86 %
Si (2s)	153.22	22.02 %
Total Percent		100.00 %

Figure D-34 Survey ESCA spectrum for tray D11 copper strap at location d+6.mm.

Wed May 20 05:26:57

M-Probe ESCA Console

User ID: MELISSA

D_11_05.MRS

Wed May 20 05:16:03 1992

Operator: M D JOHNSON

d+8mm

Spot: 400x1000µ

Resolution: 4

Energy:

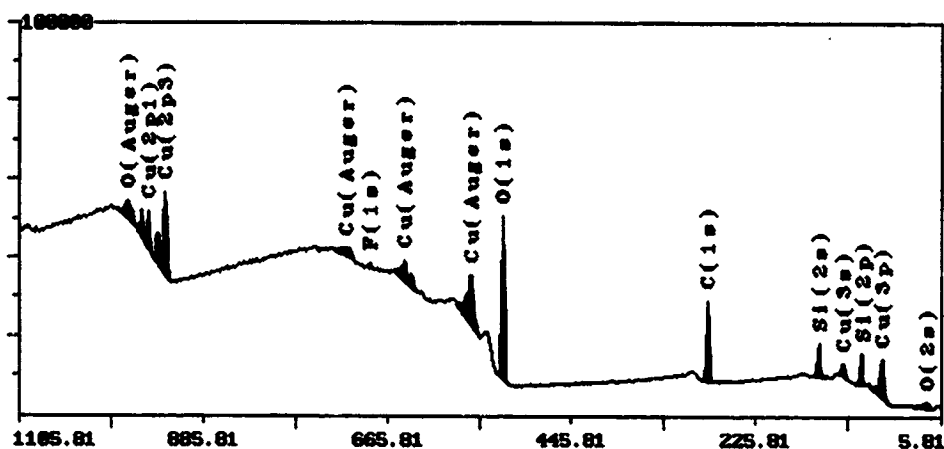
Scans: 20 of 20

Neutralizer: 3.0eV

Counts:

Region: 1/ 5

Aperture: None



Surface Composition Table Summary

File name: D_11_05.MRS

Region: 1

Description: d+8mm

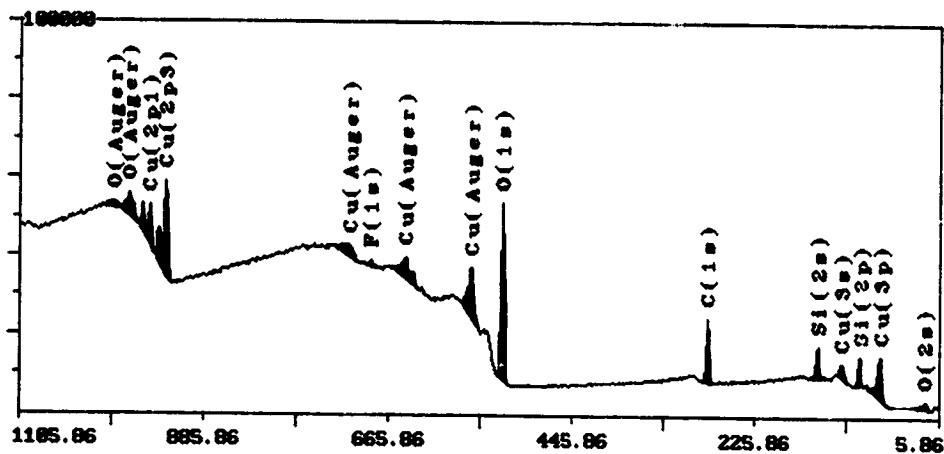
Operator: M D JOHNSON

Date: Wed May 20 05:16:03 1992

Element	Binding Energy	atom %
Cu (2p3)	935.10	8.15 %
F (1s)	689.96	0.77 %
O (1s)	532.20	37.20 %
C (1s)	285.00	35.32 %
Si (2s)	153.19	18.55 %
Total Percent		100.00 %

Figure D-35 Survey ESCA spectrum for tray D11 copper strap at location d+8.mm.

Wed May 20 08:31:05 M-Probe ESCA Console User ID: MELISSA
D_11_06.MRS Wed May 20 07:54:33 1992 Operator: M D JOHNSON
d+10mm
Spot: 100x1000µ Resolution: 4 Energy:
Scans: 20 of 20 Neutralizer: 3.0eV Counts:
Region: 1/ 5 Aperture: None



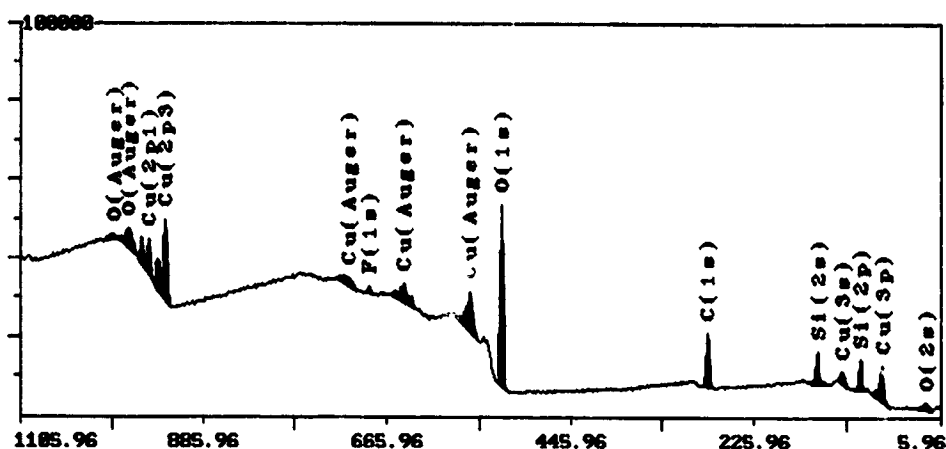
Surface Composition Table Summary

File name: D_11_06.MRS
Region: 1
Description: d+10mm
Operator: M D JOHNSON
Date: Wed May 20 07:54:33 1992

Element	Binding Energy	atom %
Cu (2p3)	935.18	9.39 %
F (1s)	690.09	0.91 %
O (1s)	532.24	40.69 %
C (1s)	285.00	30.12 %
Si (2s)	153.21	18.88 %
Total Percent		100.00 %

Figure D-36 Survey ESCA spectrum for tray D11 copper strap at location d+10.mm.

Wed May 20 10:11:37 M-Probe ESCA Console User ID: MELISSA
D_11_07.MRS Tue May 19 15:59:04 1992 Operator: M D JOHNSON
d+12mm
Spot: 400x1000µ Resolution: 4 Energy:
Scans: 20 of 20 Neutralizer: 3.0eV Counts:
Region: 1/ 5 Aperture: None



Surface Composition Table Summary

File name: D_11_07.MRS
Region: 1
Description: d+12mm
Operator: M D JOHNSON
Date: Tue May 19 15:59:04 1992

Element	Binding Energy	atom %
Cu (2p3)	935.23	8.57 %
F (1s)	690.07	1.23 %
O (1s)	532.42	41.84 %
C (1s)	285.00	27.84 %
Si (2s)	153.39	20.52 %
Total Percent		100.00 %

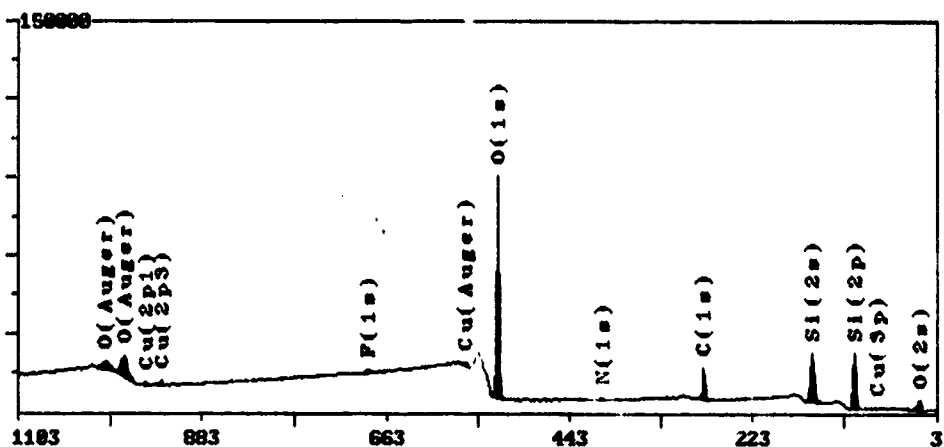
Figure D-37 Survey ESCA spectrum for tray D11 copper strap at location d+12.mm.

Tue May 26 14:29:31
D11001.MRS
d+14mm
Spot: 400x1000µ
Scans: 28 of 28
Region: 1/ 3

M-Probe ESCA Console
Tue May 26 09:18:15 1992
Resolution: 4
Neutralizer: 3.0eV
Aperture: None

User ID: LDEF
Operator: M D JOHNSON

Energy:
Counts:



Surface Composition Table Summary

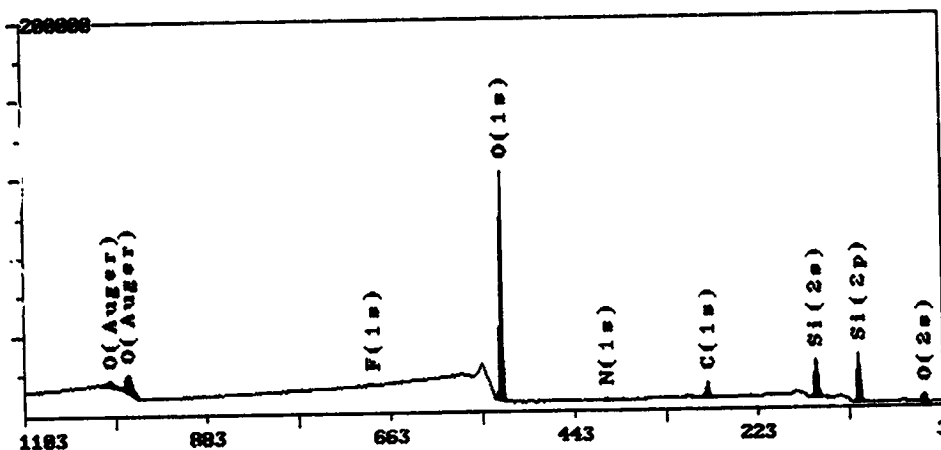
File name: D11001.MRS
Region: 1
Description: d+14mm

Operator: M D JOHNSON
Date: Tue May 26 09:18:15 1992

Element	Binding Energy	atom %
Cu (2p3)	934.21	0.22 %
F (1s)	689.25	0.66 %
N (1s)	407.79	0.69 %
C (1s)	285.10	15.77 %
Si (2s)	154.36	29.94 %
O (1s)	534.71	52.72 %
Total Percent		100.00 %

Figure D-38 Survey ESCA spectrum for tray D11 copper strap at location d+14.mm.

Tue May 26 14:28:57 M-Probe ESCA Console User ID: LDEF
 D11002.MRS Tue May 26 10:38:29 1992 Operator: M D JOHNSON
 d+16mm
 Spot: 400x1000µ Resolution: 4 Energy:
 Scans: 20 of 20 Neutralizer: 3.0eV Counts:
 Region: 1/ 3 Aperture: None



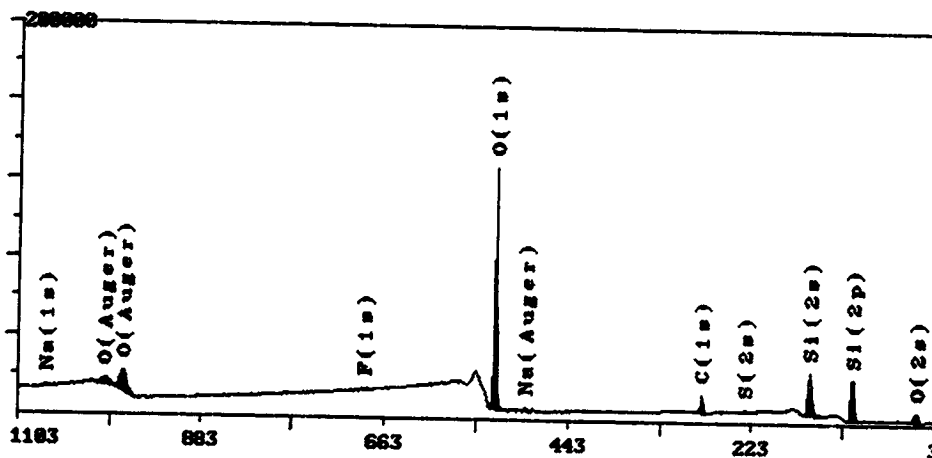
Surface Composition Table Summary

File name: D11002.MRS
 Region: 1
 Description: d+16mm
 Operator: M D JOHNSON
 Date: Tue May 26 10:38:29 1992

Element	Binding Energy	atom %
F(1s)	688.48	0.44 %
N(1s)	408.88	0.50 %
C(1s)	285.96	10.96 %
Si(2s)	155.48	31.21 %
Si(2p)	534.71	56.89 %
Total Percent		100.00 %

Figure D-39 Survey ESCA spectrum for tray D11 copper strap at location d+16mm.

Tue May 26 14:28:31 M-Probe ESCA Console User ID: LDEF
D11003.MRS Tue May 26 11:57:52 1992 Operator: M D JOHNSON
e+5mm
Spot: 400x1000µ Resolution: 4 Energy:
Scans: 20 of 20 Neutralizer: 3.0eV Counts:
Region: 1/ 3 Aperture: None



Surface Composition Table Summary

File name: D11003.MRS
Region: 1
Description: e+5mm
Operator: M D JOHNSON
Date: Tue May 26 11:57:52 1992

Element	Binding Energy	atom %
Na (1s)	1073.30	0.33 %
F (1s)	689.31	0.64 %
C (1s)	285.38	10.54 %
S (2s)	232.21	0.29 %
Si (2s)	154.71	31.38 %
O (1s)	534.71	56.81 %
Total Percent		100.00 %

Figure D-40 Survey ESCA spectrum for tray D11 copper strap at location e+5.mm.

Wed May 27 15:06:15

M-Probe ESCA Console

User ID: LDEF

D11004.MRS

Tue May 26 13:19:19 1992

Operator: M D JOHNSON

e+15mm

Spot: 400x1000µ

Resolution: 4

Energy:

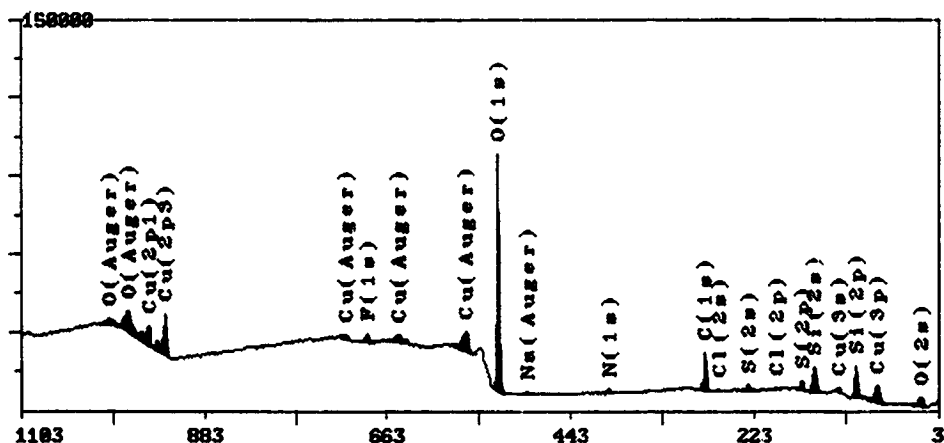
Scans: 20 of 20

Neutralizer: 3.0eV

Counts:

Region: 1/ 3

Aperture: None



Surface Composition Table Summary

File name: D11004.MRS

Region: 1

Description: e+15mm

Operator: M D JOHNSON

Date: Tue May 26 13:19:19 1992

Element	Binding Energy	atom %
F (1s)	689.91	1.46 %
O (1s)	532.58	47.67 %
N (1s)	400.36	1.06 %
C (1s)	285.15	23.14 %
Cl (2p)	198.79	0.33 %
S (2p)	169.17	4.05 %
Si (2s)	153.82	17.71 %
Cu (2p3)	934.17	4.58 %

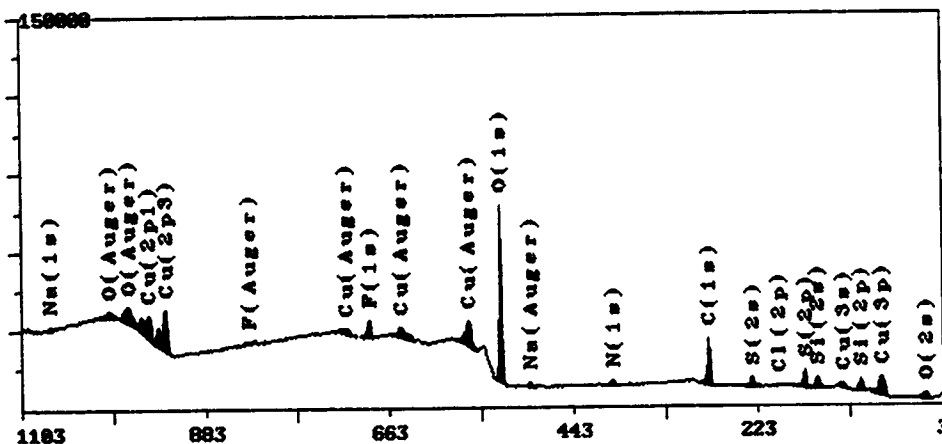
Total Percent 100.00 %

Figure D-41 Survey ESCA spectrum for tray D11 copper strap at location e+15mm.

Wed May 27 15:06:43
D11005.MRS
e+25mm
Spot: 400x1000µ
Scans: 20 of 20
Region: 1/ 3

M-Probe ESCA Console
Tue May 26 14:41:22 1992
Resolution: 4
Neutralizer: 3.0eV
Aperture: None

User ID: LDEF
Operator: M D JOHNSON
Energy:
Counts:



Surface Composition Table Summary

File name: D11005.MRS
Region: 1
Description: e+25mm

Operator: M D JOHNSON
Date: Tue May 26 14:41:22 1992

Element	Binding Energy	atom %
F (1s)	690.00	3.16 %
O (1s)	532.64	41.53 %
N (1s)	400.38	1.80 %
C (1s)	285.38	31.46 %
Cl (2p)	199.89	0.33 %
S (2p)	169.24	5.73 %
Si (2s)	154.07	8.66 %
Na (1s)	1073.69	0.43 %
Cu (2p3)	935.64	6.91 %

Total Percent 100.00 %

Figure D-42 Survey ESCA spectrum for tray D11 copper strap at location e+25.mm.

Appendix E

ESCA Survey Spectra From Selected Aluminum Tray Clamp Surfaces

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Tray: E2 Clamp: 2a-1

Element	Energy	Atom %
Si 2s	153.8	18.10
S 2s	232.3	0.89
C 1s	285.0	23.60
Mg a	307.5	0.84
N 1s	400.0	0.80
O 1s	532.4	50.99
Cr 2p ³	577.4	1.01
F 1s	689.2	0.99
Fe 2p ³	711.8	1.83
Ni 2p ³	855.9	0.36
Na 1s	1072.0	0.58

Figure E-1 Results from ESCA survey spectrum of surface location 1 of tray clamp E2.

Tray: E2 Clamp: 2a-2

Element	Energy	Atom %
Si 2s	153.8	17.55
S 2s	232.2	0.78
C 1s	285.0	24.01
Mg a	307.5	0.50
N 1s	400.0	1.00
O 1s	532.3	50.44
Cr 2p ³	577.4	1.00
Mn 2p	641.9	0.37
F 1s	689.2	1.29
Fe 2p ³	711.8	1.67
Ni 2p ³	855.9	0.53
Na 1s	1072.0	0.76

Figure E-2 Results from ESCA survey spectrum of surface location 2 of tray clamp E2.

Tray: B7 Clamp: 7a-1

Element	Energy	Atom %
Fe 3p	55.9	1.89
Si 2s	153.9	20.43
C 1s	285.1	22.00
Mg a	307.5	1.16
N 1s	400.0	1.36
Na a	497.8	2.80
O 1s	532.3	46.74
F 1s	690.3	1.64
Fe 2p ³	711.8	0.80
Ni 2p ³	855.9	0.32
Na 1s	1072.0	0.86

Figure E-3 Results from ESCA survey spectrum of surface location 1 of tray clamp B7.

Tray: B7 Clamp: 7a-2

Element	Energy	Atom %
Si 2s	153.8	16.62
S 2s	232.3	0.64
C 1s	285.1	24.55
Mg a	306.4	1.11
N 1s	400.0	0.99
O 1s	532.4	49.55
Cr 2p ³	577.4	0.55
F 1s	686.0	2.07
Fe 2p ³	711.8	1.69
Ni 2p ³	855.9	0.75
Na 1s	1072.1	1.48

Figure E-4 Results from ESCA survey spectrum of surface location 2 of tray clamp B7.

Tray: E9 Clamp: 4c-1

Element	Energy	Atom %
Si 2s	153.7	24.44
S 2s	232.3	0.79
C 1s	285.1	16.34
Mg a	307.5	0.65
K 2s	378.5	0.72
N 1s	401.1	0.94
O 1s	533.2	52.15
F 1s	689.3	2.40
Fe 2p ³	711.8	0.44
Na 1s	1072.1	1.12

Figure E-5 Results from ESCA survey spectrum of surface location 1 of tray clamp E9.

Tray: E9 Clamp: 4c-2

Element	Energy	Atom %
Si 2s	153.9	22.22
C 1s	285.1	18.95
K 2p	293.6	0.22
Mg a	306.5	0.85
N 1s	400.0	0.82
O 1s	533.1	53.06
F 1s	689.3	2.05
Fe 2p ³	711.8	0.80
Na 1s	1073.1	1.03

Figure E-6 Results from ESCA survey spectrum of surface location 2 of tray clamp E9.

Element	Energy	Atom %
Si 2s	153.9	24.42
C 1s	285.0	13.76
Mg a	306.4	0.88
O 1s	533.0	57.66
F 1s	689.3	1.17
Fe 2p ³	711.8	1.19
Ni 2p ³	855.9	0.29
Na 1s	1072.1	0.63

Figure E-7 Results from ESCA survey spectrum of surface location 1 of tray clamp A8.

Tray: A8 Clamp: 1a-2

Element	Energy	Atom %
Si 2s	153.9	24.49
C 1s	285.0	12.87
Mg a	306.5	1.00
Na a	497.8	1.18
O 1s	533.0	57.16
Cr 2p ³	576.3	0.93
F 1s	689.3	0.93
Fe 2p ³	711.8	1.06
Ni 2p ³	855.9	0.37

Figure E-8 Results from ESCA survey spectrum of surface location 2 of tray clamp A8.

Element	Energy	Atom %
Si 2s	153.8	20.84
C 1s	285.0	16.96
Mg a	306.4	0.49
K 2s	377.4	0.47
N 1s	400.0	0.67
Ti 2p	458.1	0.31
O 1s	532.3	55.86
Cr 2p ³	577.4	0.79
F 1s	689.2	0.59
Fe 2p ³	711.8	1.75
Ni 2p ³	855.9	0.39
Na 1s	1072.0	0.88

Figure E-9 Results from ESCA survey spectrum of "dark" location from tray clamp A6.

Tray: A6 Clamp: 6c-light

Element	Energy	Atom %
Si 2s	153.8	19.43
C 1s	285.0	19.96
Mg a	306.4	0.48
N 1s	400.0	0.59
O 1s	532.4	54.73
Cr 2p ³	577.4	0.60
Mn 2p	641.9	0.30
F 1s	689.2	0.52
Fe 2p ³	711.8	1.78
Ni 2p ³	855.9	0.67
Na 1s	1072.1	0.93

Figure E-10 Results from ESCA survey spectrum of "light" location from tray clamp A6.

Element	Energy	Atom %
Si 2s	153.8	21.09
C 1s	285.0	17.09
Mg a	306.5	0.81
O 1s	532.4	56.17
Cr 2p ³	577.4	0.35
Mn 2p	643.0	0.32
F 1s	689.2	0.86
Fe 2p ³	711.8	1.71
Ni 2p ³	855.9	0.67
Na 1s	1072.0	0.93

Figure E-11 Results from ESCA survey spectrum of surface location 1 of tray clamp D12.

Tray: D12 Clamp: 2a-2

Element	Energy	Atom %
Si 2s	153.8	20.98
C 1s	285.0	16.10
Mg a	306.4	0.88
Na a	497.8	1.69
O 1s	532.4	56.36
Cr 2p ³	576.4	0.30
Mn 2p	640.9	0.34
F 1s	689.2	0.72
Fe 2p ³	711.8	1.80
Ni 2p ³	855.9	0.83

Figure E-12 Results from ESCA survey spectrum of surface location 2 of tray clamp D12.

Tray: G6 Clamp: 2a-1

Element	Energy	Atom %
Si 2s	153.9	18.67
S 2s	233.3	1.65
C 1s	285.1	21.76
Mg a	306.5	0.69
Ca 2p	348.4	0.55
K 2s	378.5	1.17
N 1s	401.0	0.78
O 1s	533.0	49.09
Cr 2p ³	577.4	0.37
F 1s	689.2	2.46
Fe 2p ³	712.9	0.75
Zn 2p ³	1022.6	0.63
Na 1s	1073.0	1.43

Figure E-13 Results from ESCA survey spectrum of surface location 2 of tray clamp G6.

Tray: G6 Clamp: 2a-2

Element	Energy	Atom %
Si 2s	153.9	20.32
S 2s	233.3	1.60
C 1s	285.1	20.87
Mg a	307.5	0.85
K 2s	378.5	0.66
N 1s	401.0	1.04
O 1s	533.0	50.58
Cr 2p	576.4	0.20
F 1s	689.3	1.95
Fe 2p ³	711.8	0.47
Na 1s	1072.1	1.19

Figure E-14 Results from ESCA survey spectrum of surface location 2 of tray clamp G6.

Tray: H11 Clamp: 7a-1

Element	Energy	Atom %
Si 2p	103.3	29.09
S 2s	232.3	0.79
C 1s	285.0	11.79
Ca 2p	348.4	0.19
K 2s	378.5	0.32
O 1s	533.1	56.37
F 1s	686.0	0.70
Fe 2p ³	711.8	0.21
Na 1s	1073.1	0.52

Figure E-15 Results from ESCA survey spectrum of surface location 1 of tray clamp H11.

Tray: H11 Clamp: 7a-2

Element	Energy	Atom %
Al 2p	75.2	2.40
Si 2s	103.3	28.06
S 2s	233.3	0.71
C 1s	285.1	11.33
O 1s	533.2	56.25
F 1s	686.0	0.64
Fe 2p ³	711.8	0.22
Na 1s	1072.1	0.49

Figure E-16 Results from ESCA survey spectrum of surface location 2 of tray clamp H11.

Appendix F

Atomic concentrations as a function of depth for selected stainless steel bolts from LDEF.

Depth profiles of selected bolts are presented in tabular form. Results of analysis of four control bolts and bolts from locations A6, D2, D5, D7, E9, and H11, are included. The "depth" is reported in minutes of sputtering prior to measurement. The average sputter rates were about 150Å/minute.

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Bolt L.D.	Depth (min)	Element	Atomic Concentration (%)
Control 1-1	Surface	C	69.00
		O	8.68
		Ti	1.74
		Na	4.33
		Fe	3.63
		Si	9.88
		Ni	2.063
		Cr	0.68
Control 1-1	0.25	C	43.81
		O	18.34
		Ti	2.02
		Na	4.25
		Fe	10.37
		Si	12.92
		Ni	5.50
		Cr	2.78
Control 1-1	0.5	C	20.01
		O	17.24
		Ti	3.17
		Na	2.44
		Fe	25.97
		Si	10.14
		Ni	14.45
		Cr	6.58

Figure F-1. Atomic concentrations at selected depths for stainless steel control bolt 1, area 1.

<u>Bolt</u> <u>I.D.</u>	<u>Depth</u> <u>(in)</u>	<u>Element</u>	<u>Atomic</u> <u>Concentration (%)</u>
Control 1-1	0.75	C	12.13
		O	9.87
		Ti	2.47
		Na	1.17
		Fe	39.97
		Si	5.58
		Ni	19.57
		Cr	9.25
Control 1-1	1.0	C	10.67
		O	5.46
		Ti	3.67
		Na	1.70
		Fe	46.35
		Si	2.98
		Ni	18.96
		Cr	10.21
Control 1-1	1.25	C	7.92
		O	4.05
		Ti	2.93
		Na	1.36
		Fe	49.60
		Si	2.73
		Ni	20.15
		Cr	11.26

Figure F-1 (continued).

Atomic concentrations at selected depths for stainless steel control bolt 1, area 1.

Bolt L.D.	Depth (min)	Element	Atomic Concentration (%)
Control 1-1	1.5	C	6.46
		O	2.09
		Ti	3.46
		Na	1.44
		Fe	52.33
		Si	2.22
		Ni	20.70
		Cr	11.29
Control 1-1	1.75	C	6.76
		O	2.09
		Ti	3.09
		Na	1.36
		Fe	51.79
		Si	2.12
		Ni	21.53
		Cr	11.25
Control 1-1	2.0	C	5.58
		O	1.89
		Ti	2.69
		Na	1.27
		Fe	52.97
		Si	2.10
		Ni	21.05
		Cr	12.44

Figure F-1 (continued).

Atomic concentrations at selected depths for stainless steel control bolt 1, area 1.

Bolt I.D.	Depth (min)	Element	Atomic Concentration (%)
Control 1-2	Surface	C	79.97
		O	4.98
		Ti	1.31
		Na	4.16
		Fe	3.85
		Si	3.15
		Ni	1.56
		Cr	1.03
Control 1-2	0.25	C	63.88
		O	11.02
		Ti	1.50
		Na	5.91
		Fe	8.40
		Si	4.16
		Ni	3.92
		Cr	1.22
Control 1-2	0.50	C	45.48
		O	15.45
		Ti	1.58
		Na	3.81
		Fe	16.11
		Si	6.28
		Ni	7.67
		Cr	3.62

Figure F-2. Atomic concentrations at selected depths for stainless steel control bolt 1, area 2.

<u>Bolt</u> <u>L.D.</u>	<u>Depth</u> <u>(min)</u>	<u>Element</u>	<u>Atomic</u> <u>Concentration (%)</u>
Control 1-2	0.75	C	31.15
		O	14.56
		Ti	2.05
		Na	3.22
		Fe	26.82
		Si	5.08
		Ni	11.68
		Cr	5.44
Control 1-2	1.0	C	23.65
		O	11.73
		Ti	2.20
		Na	2.22
		Fe	33.75
		Si	3.64
		Ni	15.95
		Cr	6.85
Control 1-2	1.25	C	20.88
		O	9.45
		Ti	2.04
		Na	2.16
		Fe	38.60
		Si	3.51
		Ni	15.98
		Cr	7.38

Figure F-2 (continued).

Atomic concentrations at selected depths for stainless steel control bolt 1, area 2.

Bolt I.D.	Depth (min)	Element	Atomic Concentration (%)
Control 1-2	1.5	C	18.07
		O	8.30
		Ti	2.01
		Na	2.10
		Fe	40.44
		Si	3.36
		Ni	17.64
		Cr	8.08
Control 1-2	1.75	C	14.64
		O	7.41
		Ti	2.39
		Na	1.51
		Fe	43.17
		Si	3.17
		Ni	18.79
		Cr	8.92
Control 1-2	2.0	C	13.18
		O	6.93
		Ti	2.35
		Na	1.38
		Fe	45.68
		Si	2.71
		Ni	18.39
		Cr	9.40

Figure F-2 (continued).

Atomic concentrations at selected depths for stainless steel control bolt 1, area 2.

<u>Bolt L.D.</u>	<u>Depth (min)</u>	<u>Element</u>	<u>Atomic Concentration (%)</u>
Control 1-2	2.25	C	14.15
		O	4.27
		Ti	2.44
		Na	1.86
		Fe	46.87
		Si	2.89
		Ni	18.53
		Cr	8.99
Control 1-2	2.5	C	12.68
		O	4.39
		Ti	2.78
		Na	1.48
		Fe	47.36
		Si	2.42
		Ni	19.06
		Cr	9.83
Control 1-2	2.75	C	10.21
		O	4.47
		Ti	2.35
		Na	1.42
		Fe	49.85
		Si	2.49
		Ni	19.50
		Cr	9.71

Figure F-2 (continued).

Atomic concentrations at selected depths for stainless steel control bolt 1, area 2.

Bolt L.D.	Depth (min)	Element	Atomic Concentration (%)
Control 1-2	3.0	C	9.07
		O	3.78
		Ti	1.87
		Na	1.74
		Fe	50.86
		Si	2.16
		Ni	20.42
		Cr	10.10
Control 1-2	3.25	C	10.63
		O	3.26
		Ti	2.18
		Na	1.34
		Fe	50.72
		Si	1.83
		Ni	20.75
		Cr	9.29
Control 1-2	3.5	C	10.05
		O	3.98
		Ti	2.863
		Na	1.17
		Fe	48.88
		Si	2.11
		Ni	21.01
		Cr	9.97

Figure F-2 (continued).

Atomic concentrations at selected depths for stainless steel
control bolt 1, area 2.

<u>Bolt</u> <u>L.D.</u>	<u>Depth</u> <u>(min)</u>	<u>Element</u>	<u>Atomic</u> <u>Concentration (%)</u>
Control 1-2	3.75	C	8.48
		O	3.81
		Ti	2.80
		Na	1.76
		Fe	49.77
		Si	1.94
		Ni	21.85
		Cr	9.60
Control 1-2	4.0	C	7.51
		O	3.86
		Ti	2.33
		Na	1.54
		Fe	51.54
		Si	2.37
		Ni	21.10
		Cr	9.75

Figure F-2 (continued).

Atomic concentrations at selected depths for stainless steel control bolt 1, area 2.

<u>Bolt L.D.</u>	<u>Depth (min)</u>	<u>Element</u>	<u>Atomic Concentration (%)</u>
Control 2-1	Surface	C	71.13
		O	8.42
		Ti	2.64
		Na	6.22
		Fe	5.53
		Si	2.79
		Ni	2.22
		Cr	1.05
Control 2-1	0.25	C	55.88
		O	12.98
		Ti	2.27
		Na	5.75
		Fe	13.55
		Si	4.55
		Ni	4.20
		Cr	0.82
Control 2-1	0.5	C	41.85
		O	15.52
		Ti	3.01
		Na	4.79
		Fe	20.24
		Si	4.59
		Ni	7.84
		Cr	2.16

Figure F-3. Atomic concentrations at selected depths for stainless steel control bolt 2, area 1.

<u>Bolt L.D.</u>	<u>Depth (min)</u>	<u>Element</u>	<u>Atomic Concentration (%)</u>
Control 2-1	0.75	C	33.76
		O	14.47
		Ti	2.59
		Na	3.60
		Fe	26.58
		Si	5.19
		Ni	10.20
		Cr	3.62
Control 2-1	1.0	C	30.47
		O	12.66
		Ti	2.54
		Na	3.14
		Fe	30.35
		Si	5.36
		Ni	12.29
		Cr	3.20
Control 2-1	1.25	C	27.66
		O	12.28
		Ti	2.63
		Na	2.29
		Fe	31.79
		Si	5.34
		Ni	12.39
		Cr	5.62

Figure F-3 (continued).

Atomic concentrations at selected depths for stainless steel control bolt 2, area 1.

<u>Bolt I.D.</u>	<u>Depth (min)</u>	<u>Element</u>	<u>Atomic Concentration (%)</u>
Control 2-1	1.5	C	23.64
		O	12.35
		Ti	1.85
		Na	2.23
		Fe	35.26
		Si	5.29
		Ni	14.02
		Cr	5.37
Control 2-1	1.75	C	20.49
		O	10.76
		Ti	2.56
		Na	2.34
		Fe	36.71
		Si	5.78
		Ni	14.27
		Cr	7.10
Control 2-1	2.0	C	19.16
		O	11.09
		Ti	2.79
		Na	1.75
		Fe	38.77
		Si	5.36
		Ni	14.62
		Cr	6.45

Figure F-3 (continued).

Atomic concentrations at selected depths for stainless steel
control bolt 2, area 1.

<u>Bolt I.D.</u>	<u>Depth (min)</u>	<u>Element</u>	<u>Atomic Concentration (%)</u>
Control 2-1	2.25	C	19.18
		O	7.88
		Ti	2.52
		Na	1.95
		Fe	41.28
		Si	3.72
		Ni	16.11
		Cr	7.36
Control 2-1	2.5	C	15.45
		O	7.85
		Ti	2.64
		Na	? 14
		Fe	42.11
		Si	4.01
		Ni	17.56
		Cr	7.24
Control 2-1	2.75	C	15.65
		O	7.42
		Ti	2.40
		Na	1.41
		Fe	43.44
		Si	3.32
		Ni	17.95
		Cr	8.41

Figure F-3 (continued).

Atomic concentrations at selected depths for stainless steel control bolt 2, area 1.

Bolt L.D.	Depth (min)	Element	Atomic Concentration (%)
Control 2-1	3.0	C	14.88
		O	6.98
		Ti	3.06
		Na	1.22
		Fe	44.47
		Si	3.56
		Ni	18.00
		Cr	7.84
Control 2-1	3.25	C	14.23
		O	6.32
		Ti	2.72
		Na	1.60
		Fe	45.24
		Si	2.73
		Ni	19.17
		Cr	7.99
Control 2-1	3.5	C	12.86
		O	7.12
		Ti	2.58
		Na	1.60
		Fe	43.41
		Si	3.51
		Ni	19.78
		Cr	9.14

Figure F-3 (continued).

Atomic concentrations at selected depths for stainless steel
control bolt 2, area 1.

Bolt L.D.	Depth (min)	Element	Atomic Concentration (%)
Control 2-1	3.75	C	12.16
		O	7.18
		Ti	3.22
		Na	1.56
		Fe	44.77
		Si	3.12
		Ni	19.57
		Cr	8.42
Control 2-1	4.0	C	11.56
		O	6.54
		Ti	3.40
		Na	1.91
		Fe	45.35
		Si	2.84
		Ni	19.44
		Cr	8.96

Figure F-3 (continued).

**Atomic concentrations at selected depths for stainless steel
control bolt 2, area 1.**

Bolt L.D.	Depth (min)	Element	Atomic Concentration (%)
Control 2-2	Surface	C	75.93
		O	6.20
		Ti	2.24
		Na	4.33
		Fe	4.27
		Si	4.49
		Ni	1.83
		Cr	0.72
Control 2-2	0.25	C	63.07
		O	12.33
		Ti	1.93
		Na	6.26
		Fe	5.63
		Si	6.10
		Ni	3.33
		Cr	1.33
Control 2-2	0.5	C	49.44
		O	13.39
		Ti	1.61
		Na	3.71
		Fe	14.89
		Si	6.15
		Ni	7.22
		Cr	3.59

Figure F-4. Atomic concentrations at selected depths for stainless steel control bolt 2, area 2.

Bolt L.D.	Depth (min)	Element	Atomic Concentration (%)
Control 2-2	0.75	C	40.45
		O	10.01
		Ti	2.77
		Na	2.97
		Fe	21.23
		Si	5.73
		Ni	12.16
		Cr	4.68
Control 2-2	1.0	C	35.54
		O	7.78
		Ti	2.82
		Na	2.50
		Fe	28.02
		Si	4.41
		Ni	12.88
		Cr	6.05
Control 2-2	1.25	C	32.13
		O	6.77
		Ti	2.16
		Na	2.31
		Fe	31.88
		Si	3.67
		Ni	14.42
		Cr	6.66

Figure F-4 (continued).

Atomic concentrations at selected depths for stainless steel control bolt 2, area 2.

Bolt L.D.	Depth (min)	Element	Atomic Concentration (%)
Control 2-2	1.5	C	33.06
		O	6.91
		Ti	2.71
		Na	2.49
		Fe	29.88
		Si	3.63
		Ni	14.23
		Cr	7.09
Control 2-2	1.75	C	28.99
		O	6.71
		Ti	2.67
		Na	2.10
		Fe	34.24
		Si	3.67
		Ni	14.83
		Cr	6.79
Control 2-2	2.0	C	28.53
		O	6.22
		Ti	2.34
		Na	2.22
		Fe	34.41
		Si	3.56
		Ni	15.35
		Cr	7.38

Figure F-4 (continued). Atomic concentrations at selected depths for stainless steel control bolt 2, area 2.

Bolt L.D.	Depth (min)	Element	Atomic Concentration (%)
Control 2-2	2.25	C	24.55
		O	5.68
		Ti	2.169
		Na	1.88
		Fe	36.31
		Si	3.86
		Ni	16.52
		Cr	8.11
Control 2-2	2.5	C	24.22
		O	6.063
		Ti	2.20
		Na	1.66
		Fe	35.94
		Si	4.56
		Ni	16.51
		Cr	8.06
Control 2-2	2.75	C	24.42
		O	5.40
		Ti	3.21
		Na	2.10
		Fe	37.16
		Si	3.70
		Ni	16.42
		Cr	7.59

Figure F-4 (continued).

**Atomic concentrations at selected depths for stainless steel
control bolt 2, area 2.**

<u>Bolt L.D.</u>	<u>Depth (min)</u>	<u>Element</u>	<u>Atomic Concentration (%)</u>
Control 2-2	3.0	C	24.29
		O	5.85
		Ti	3.70
		Na	1.79
		Fe	37.61
		Si	2.86
		Ni	15.70
		Cr	8.21
Control 2-2	3.25	C	21.65
		O	4.74
		Ti	2.74
		Na	1.63
		Fe	40.11
		Si	4.25
		Ni	16.40
		Cr	8.48
Control 2-2	3.5	C	20.75
		O	4.90
		Ti	2.66
		Na	1.77
		Fe	41.33
		Si	3.63
		Ni	16.55
		Cr	8.42

Figure F-4 (continued).

Atomic concentrations at selected depths for stainless steel control bolt 2, area 2.

<u>Bolt L.D.</u>	<u>Depth (min)</u>	<u>Element</u>	<u>Atomic Concentration (%)</u>
Control 2-2	3.75	C	20.26
		O	4.73
		Ti	2.95
		Na	1.52
		Fe	42.21
		Si	3.05
		Ni	16.60
		Cr	8.68
Control 2-2	4.0	C	19.08
		O	4.86
		Ti	2.52
		Na	1.55
		Fe	42.88
		Si	2.67
		Ni	18.39
		Cr	8.04
Control 2-2	5.0	C	16.02
		O	3.53
		Ti	3.49
		Na	1.56
		Fe	43.81
		Si	2.33
		Ni	19.94
		Cr	9.32

Figure F-4 (continued).

**Atomic concentrations at selected depths for stainless steel
control bolt 2, area 2.**

<u>Bolt L.D.</u>	<u>Depth (min)</u>	<u>Element</u>	<u>Atomic Concentration (%)</u>
Control 2-2	6.0	C	12.23
		O	3.25
		Ti	2.83
		Na	1.58
		Fe	47.27
		Si	2.03
		Ni	20.21
		Cr	10.59

Figure F-4 (continued).

Atomic concentrations at selected depths for stainless steel control bolt 2, area 2.

Bolt L.D.	Depth (min)	Element	Atomic Concentration (%)
Control 3-1	Surface	C	46.38
		O	21.22
		Ti	2.41
		Na	3.40
		Fe	5.54
		Si	18.21
		Ni	2.18
		Cr	0.65
Control 3-1	0.25	C	17.63
		O	28.17
		Ti	2.55
		Na	3.45
		Fe	16.97
		Si	21.85
		Ni	6.10
		Cr	3.28
Control 3-1	0.5	C	15.55
		O	18.10
		Ti	3.09
		Na	1.70
		Fe	29.20
		Si	12.12
		Ni	13.90
		Cr	6.34

Figure F-5. Atomic concentrations at selected depths for stainless steel control bolt 3, area 1.

Bolt L.D.	Depth (min)	Element	Atomic Concentration (%)
Control 3-1	0.75	C	11.91
		O	10.46
		Ti	2.96
		Na	2.00
		Fe	39.81
		Si	7.25
		Ni	17.28
		Cr	8.33
Control 3-1	1.0	C	9.61
		O	7.37
		Ti	3.48
		Na	1.19
		Fe	43.26
		Si	4.97
		Ni	19.58
		Cr	10.53
Control 3-1	1.25	C	7.19
		O	4.77
		Ti	2.79
		Na	1.36
		Fe	48.19
		Si	3.67
		Ni	19.30
		Cr	12.73

Figure F-5 (continued).

Atomic concentrations at selected depths for stainless steel control bolt 3, area 1.

<u>Bolt</u> <u>L.D.</u>	<u>Depth</u> <u>(min)</u>	<u>Element</u>	<u>Atomic</u> <u>Concentration (%)</u>
Control 3-1	1.5	C	6.98
		O	3.25
		Ti	3.97
		Na	0.97
		Fe	51.37
		Si	2.25
		Ni	19.46
		Cr	11.77
Control 3-1	1.75	C	6.26
		O	1.54
		Ti	2.99
		Na	1.53
		Fe	51.51
		Si	2.77
		Ni	20.69
		Cr	12.71
Control 3-1	2.0	C	4.97
		O	1.79
		Ti	2.47
		Na	1.64
		Fe	53.25
		Si	1.79
		Ni	21.07
		Cr	13.02

Figure F-5 (continued).

Atomic concentrations at selected depths for stainless steel control bolt 3, area 1.

<u>Bolt L.D.</u>	<u>Depth (min)</u>	<u>Element</u>	<u>Atomic Concentration (%)</u>
Control 3-2	Surface	C	55.50
		O	15.68
		Ti	2.37
		Na	6.61
		Fe	6.90
		Si	8.80
		Ni	2.87
		Cr	1.27
Control 3-2	0.25	C	14.28
		O	28.79
		Ti	3.35
		Na	3.82
		Fe	21.06
		Si	11.21
		Ni	10.07
		Cr	7.43
Control 3-2	0.5	C	11.14
		O	15.21
		Ti	4.29
		Na	1.85
		Fe	34.94
		Si	7.86
		Ni	17.66
		Cr	7.05

Figure F-6. Atomic concentrations at selected depths for stainless steel control bolt 3, area 2.

Bolt L.D.	Depth (in.)	Element	Atomic Concentration (%)
Control 3-2	0.75	C	12.26
		O	10.90
		Ti	2.53
		Na	2.24
		Fe	39.43
		Si	7.01
		Ni	18.14
		Cr	7.48
Control 3-2	1.0	C	13.00
		O	9.17
		Ti	2.85
		Na	2.19
		Fe	41.95
		Si	6.01
		Ni	17.09
		Cr	7.73
Control 3-2	1.25	C	10.29
		O	7.85
		Ti	2.25
		Na	1.98
		Fe	44.34
		Si	6.31
		Ni	18.42
		Cr	8.56

Figure F-6 (continued).

Atomic concentrations at selected depths for stainless steel control bolt 3, area 2.

<u>Bolt I.D.</u>	<u>Depth (min)</u>	<u>Element</u>	<u>Atomic Concentration (%)</u>
Control 3-2	1.5	C	9.60
		O	7.01
		Ti	3.44
		Na	1.77
		Fe	44.93
		Si	5.46
		Ni	18.70
		Cr	9.09
Control 3-2	1.75	C	9.16
		O	7.07
		Ti	2.96
		Na	1.60
		Fe	45.56
		Si	5.96
		Ni	18.16
		Cr	9.53
Control 3-2	2.0	C	7.95
		O	6.99
		Ti	2.90
		Na	2.10
		Fe	46.57
		Si	5.73
		Ni	18.68
		Cr	9.09

Figure F-6 (continued).

Atomic concentrations at selected depths for stainless steel control bolt 3, area 2.

Bolt I.D.	Depth (min)	Element	Atomic Concentration (%)
Control 3-2	2.25	C	9.11
		O	6.23
		Ti	3.35
		Na	1.74
		Fe	46.91
		Si	4.04
		Ni	19.09
		Cr	9.53
Control 3-2	2.5	C	9.83
		O	6.30
		Ti	2.38
		Na	1.92
		Fe	47.50
		Si	4.33
		Ni	18.28
		Cr	9.45
Control 3-2	2.75	C	8.66
		O	5.42
		Ti	3.35
		Na	1.30
		Fe	48.37
		Si	4.33
		Ni	19.04
		Cr	9.53

Figure F-6 (continued).

Atomic concentrations at selected depths for stainless steel control bolt 3, area 2.

Bolt L.D.	Depth (min)	Element	Atomic Concentration (%)
Control 3-2	3.0	C	8.49
		O	5.57
		Ti	3.40
		Na	1.06
		Fe	46.89
		Si	4.39
		Ni	19.69
		Cr	10.49
Control 3-2	3.25	C	8.61
		O	5.41
		Ti	4.01
		Na	1.43
		Fe	46.99
		Si	3.96
		Ni	19.63
		Cr	9.96
Control 3-2	3.5	C	9.53
		O	5.33
		Ti	3.24
		Na	1.34
		Fe	48.08
		Si	3.73
		Ni	18.26
		Cr	10.50

Figure F-6 (continued).

Atomic concentrations at selected depths for stainless steel control bolt 3, area 2.

Bolt L.D.	Depth (min)	Element	Atomic Concentration (%)
Control 3-2	3.75	C	8.53
		O	4.82
		Ti	3.16
		Na	1.50
		Fe	48.92
		Si	3.74
		Ni	19.64
		Cr	9.69
Control 3-2	4.0	C	7.97
		O	4.26
		Ti	3.38
		Na	1.59
		Fe	49.40
		Si	3.18
		Ni	19.70
		Cr	10.53
Control 3-2	5.0	C	8.26
		O	4.32
		Ti	2.34
		Na	1.05
		Fe	48.98
		Si	3.84
		Ni	19.95
		Cr	11.26

Figure F-6 (continued).

Atomic concentrations at selected depths for stainless steel control bolt 3, area 2.

<u>Bolt</u> <u>L.D.</u>	<u>Depth</u> <u>(min)</u>	<u>Element</u>	<u>Atomic</u> <u>Concentration (%)</u>
Control 3-2	6.0	C	7.53
		O	2.87
		Ti	2.71
		Na	1.09
		Fe	51.36
		Si	2.72
		Ni	20.83
		Cr	10.88

Figure F-5 (continued).

Atomic concentrations at selected depths for stainless steel control bolt 3, area 1.

<u>Bolt L.D.</u>	<u>Depth (min)</u>	<u>Element</u>	<u>Atomic Concentration (%)</u>
Control 4-1	Surface	C	73.00
		O	7.75
		Ti	1.57
		Na	2.97
		Fe	7.81
		Si	3.14
		Ni	3.01
		Cr	0.75
Control 4-1	0.25	C	29.02
		O	19.12
		Ti	1.90
		Na	2.11
		Fe	26.32
		Si	3.02
		Ni	12.45
		Cr	6.06
Control 4-1	0.5	C	11.05
		O	5.88
		Ti	2.74
		Na	1.17
		Fe	47.52
		Si	1.83
		Ni	21.48
		Cr	8.33

Figure F-7. Atomic concentrations at selected depths for stainless steel control bolt 4, area 1.

<u>Bolt</u> <u>L.D.</u>	<u>Depth</u> <u>(min)</u>	<u>Element</u>	<u>Atomic</u> <u>Concentration (%)</u>
Control 4-1	0.75	C	8.03
		O	1.87
		Ti	1.99
		Na	1.23
		Fe	53.10
		Si	1.56
		Ni	23.07
		Cr	9.15
Control 4-1	1.0	C	7.01
		O	1.27
		Ti	2.70
		Na	1.19
		Fe	56.07
		Si	1.62
		Ni	21.05
		Cr	9.09
Control 4-1	1.25	C	4.90
		O	0.85
		Ti	2.88
		Na	1.33
		Fe	55.60
		Si	2.33
		Ni	22.17
		Cr	9.95

Figure F-7 (continued).

Atomic concentrations at selected depths for stainless steel control bolt 4, area 1.

<u>Bolt</u> <u>L.D.</u>	<u>Depth</u> <u>(min)</u>	<u>Element</u>	<u>Atomic</u> <u>Concentration (%)</u>
Control 4-1	1.5	C	4.37
		O	0.56
		Ti	3.05
		Na	1.12
		Fe	56.33
		Si	2.15
		Ni	22.00
		Cr	10.41
Control 4-1	1.75	C	4.19
		O	0.77
		Ti	2.45
		Na	0.99
		Fe	55.95
		Si	1.24
		Ni	23.34
		Cr	11.08
Control 4-1	2.0	C	4.20
		O	0.81
		Ti	2.40
		Na	1.47
		Fe	55.55
		Si	1.99
		Ni	22.93
		Cr	10.66

Figure F-7 (continued).

Atomic concentrations at selected depths for stainless steel control bolt 4, area 1.

Bolt L.D.	Depth (min)	Element	Atomic Concentration (%)
Control 4-2	Surface	C	66.99
		O	10.46
		Ti	1.25
		Na	4.94
		Fe	3.49
		Si	10.04
		Ni	2.11
		Cr	0.71
Control 4-2	0.25	C	38.68
		O	23.67
		Ti	1.72
		Na	4.73
		Fe	9.67
		Si	16.66
		Ni	3.36
		Cr	1.50
Control 4-2	0.5	C	18.74
		O	22.18
		Ti	2.04
		Na	2.22
		Fe	24.53
		Si	11.31
		Ni	12.95
		Cr	6.03

Figure F-8. Atomic concentrations at selected depths for stainless steel control bolt 4, area 2.

Bolt L.D.	Depth (min)	Element	Atomic Concentration (%)
Control 4-2	0.75	C	11.98
		O	12.11
		Ti	2.91
		Na	1.63
		Fe	38.69
		Si	8.31
		Ni	18.52
		Cr	5.85
Control 4-2	1.0	C	10.14
		O	8.56
		Ti	1.94
		Na	1.93
		Fe	47.50
		Si	4.87
		Ni	18.24
		Cr	6.82
Control 4-2	1.25	C	7.78
		O	6.78
		Ti	1.99
		Na	1.51
		Fe	49.42
		Si	4.41
		Ni	19.99
		Cr	8.11

Figure F-8 (continued). Atomic concentrations at selected depths for stainless steel control bolt 4, area 2.

Bolt L.D.	Depth (min)	Element	Atomic Concentration (%)
Control 4-2	1.5	C	7.35
		O	5.16
		Ti	2.02
		Na	1.32
		Fe	52.36
		Si	4.22
		Ni	19.62
		Cr	7.94
Control 4-2	1.75	C	6.35
		O	4.69
		Ti	2.18
		Na	2.12
		Fe	51.20
		Si	2.65
		Ni	19.63
		Cr	8.18
Control 4-2	2.0	C	6.46
		O	4.79
		Ti	1.86
		Na	1.36
		Fe	54.40
		Si	2.72
		Ni	20.02
		Cr	8.39

Figure F-8 (continued).

Atomic concentrations at selected depths for stainless steel control bolt 4, area 2.

<u>Bolt</u> <u>L.D.</u>	<u>Depth</u> <u>(min)</u>	<u>Element</u>	<u>Atomic</u> <u>Concentration (%)</u>
Control 4-2	2.25	C	5.49
		O	3.08
		Ti	2.21
		Na	1.59
		Fe	56.07
		Si	3.00
		Ni	20.18
		Cr	8.38
Control 4-2	2.5	C	4.45
		O	3.51
		Ti	2.11
		Na	1.41
		Fe	56.01
		Si	3.29
		Ni	20.23
		Cr	8.99
Control 4-2	2.75	C	5.05
		O	3.07
		Ti	2.06
		Na	1.01
		Fe	57.18
		Si	2.52
		Ni	19.94
		Cr	9.18

Figure F-8 (continued).

Atomic concentrations at selected depths for stainless steel control bolt 4, area 2.

<u>Bolt L.D.</u>	<u>Depth (min)</u>	<u>Element</u>	<u>Atomic Concentration (%)</u>
Control 4-2	3.0	C	4.39
		O	2.75
		Ti	2.39
		Na	1.12
		Fe	56.71
		Si	1.61
		Ni	21.68
		Cr	9.35
Control 4-2	3.25	C	4.63
		O	3.02
		Ti	2.53
		Na	1.33
		Fe	56.88
		Si	2.09
		Ni	20.67
		Cr	8.85
Control 4-2	3.5	C	3.90
		O	2.82
		Ti	2.12
		Na	1.39
		Fe	56.09
		Si	2.06
		Ni	21.38
		Cr	10.24

Figure F-8 (continued).

Atomic concentrations at selected depths for stainless steel
control bolt 4, area 2.

Bolt I.D.	Depth (min)	Element	Atomic Concentration (%)
Control 4-2	3.75	C	4.62
		O	3.33
		Ti	2.24
		Na	1.12
		Fe	56.81
		Si	1.92
		Ni	20.47
		Cr	9.48
Control 4-2	4.0	C	3.60
		O	2.27
		Ti	2.32
		Na	1.44
		Fe	56.44
		Si	2.58
		Ni	21.62
		Cr	9.73

Figure F-8 (continued).

**Atomic concentrations at selected depths for stainless steel
control bolt 4, area 2.**

<u>Bolt L.D.</u>	<u>Depth (min)</u>	<u>Element</u>	<u>Atomic Concentration (%)</u>
A6-6C	Surface	C	25.56
		O	29.98
		Ca	0.83
		Ti	1.60
		Fe	17.66
		Si	11.71
		Ni	7.75
		Cr	2.71
		K	2.20
A6-6C	0.25	C	5.39
		O	25.83
		Ca	1.42
		Ti	2.98
		Fe	34.55
		Si	6.89
		Ni	14.98
		Cr	6.22
		K	1.73
A6-6C	0.5	C	6.49
		O	12.41
		Ca	0.72
		Ti	4.12
		Fe	43.09
		Si	5.17
		Ni	20.35
		Cr	6.51
		K	1.14

Figure F-9. Atomic concentrations at selected depths for stainless steel bolt A6-6c.

Bolt L.D.	Depth (min)	Element	Atomic Concentration (%)
A6-6C	0.75	C	5.42
		O	7.49
		Ca	0.64
		Ti	3.74
		Fe	50.11
		Si	3.51
		Ni	22.09
		Cr	6.00
		K	1.01
A6-6C	1.0	C	4.96
		O	6.42
		Ca	0.94
		Ti	3.77
		Fe	50.59
		Si	3.40
		Ni	22.02
		Cr	6.80
		K	1.10
A6-6C	1.25	C	4.40
		O	5.81
		Ca	1.07
		Ti	4.84
		Fe	52.05
		Si	3.34
		Ni	20.74
		Cr	6.94
		K	0.82

Figure F-9 (continued).

Atomic concentrations at selected depths for stainless steel bolt A6-6c.

Bolt L.D.	Depth (min)	Element	Atomic Concentration (%)
A6-6C	1.5	C	5.17
		O	5.10
		Ca	0.83
		Ti	4.72
		Fe	51.59
		Si	3.60
		Ni	21.33
		Cr	6.77
		K	0.89
A6-6C	1.75	C	4.38
		O	5.14
		Ca	0.71
		Ti	4.20
		Fe	52.73
		Si	3.25
		Ni	20.86
		Cr	8.06
		K	0.67
A6-6C	2.0	C	4.35
		O	4.91
		Ca	0.93
		Ti	4.34
		Fe	53.90
		Si	3.40
		Ni	19.61
		Cr	7.74
		K	0.82

Figure F-9 (continued).

Atomic concentrations at selected depths for stainless steel bolt A6-6c.

Bolt L.D.	Depth (min)	Element	Atomic Concentration (%)
A6-6C	2.25	C	6.70
		O	5.03
		Ca	1.16
		Ti	5.93
		Fe	49.47
		Si	3.57
		Ni	19.00
		Cr	8.00
		K	1.14
A6-6C	2.5	C	6.60
		O	4.97
		Ca	1.01
		Ti	5.39
		Fe	49.70
		Si	3.27
		Ni	19.51
		Cr	8.20
		K	1.33
A6-6C	2.75	C	5.99
		O	4.99
		Ca	0.77
		Ti	5.47
		Fe	50.76
		Si	3.31
		Ni	19.55
		Cr	8.05
		K	1.12

Figure F-9 (continued).

Atomic concentrations at selected depths for stainless steel
bolt A6-6c.

Bolt L.D.	Depth (min)	Element	Atomic Concentration (%)
A6-6C	3.0	C	5.37
		O	4.43
		Ca	0.76
		Ti	5.73
		Fe	51.21
		Si	3.18
		Ni	19.77
		Cr	8.42
		K	1.14
A6-6C	3.25	C	5.48
		O	4.43
		Ca	0.89
		Ti	5.27
		Fe	51.47
		Si	2.48
		Ni	20.57
		Cr	8.39
		K	1.00
A6-6C	3.5	C	5.89
		O	4.70
		Ca	1.17
		Ti	5.17
		Fe	50.61
		Si	2.47
		Ni	19.92
		Cr	9.16
		K	0.90

Figure F-9 (continued).

Atomic concentrations at selected depths for stainless steel
bolt A6-6c.

Bolt L.D.	Depth (min)	Element	Atomic Concentration (%)
A6-6C	3.75	C	5.08
		O	4.75
		Ca	1.30
		Ti	4.72
		Fe	52.90
		Si	2.37
		Ni	19.07
		Cr	8.90
		K	0.91
A6-6C	4.0	C	5.06
		O	4.00
		Ca	1.26
		Ti	4.79
		Fe	53.12
		Si	2.26
		Ni	19.82
		Cr	8.84
		K	0.85

Figure F-9 (continued).

**Atomic concentrations at selected depths for stainless steel
bolt A6-6c.**

<u>Bolt L.D.</u>	<u>Depth (min)</u>	<u>Element</u>	<u>Atomic Concentration (%)</u>
D2-4C-1	Surface	C	32.70
		O	24.04
		S	0.66
		Na	2.64
		Fe	20.81
		Si	9.10
		Ni	7.53
		Cr	2.52
D2-4C-1	0.25	C	8.75
		O	24.34
		S	0.51
		Na	1.47
		Fe	35.78
		Si	4.12
		Ni	18.17
		Cr	6.85
D2-4C-1	0.50	C	7.10
		O	12.17
		S	0.44
		Na	1.36
		Fe	46.13
		Si	3.05
		Ni	22.94
		Cr	6.80

Figure F-10. Atomic concentrations at selected depths for stainless steel bolt D2-4c, area 1.

Bolt L.D.	Depth (min)	Element	Atomic Concentration (%)
D2-4C-1	0.75	C	6.22
		O	8.62
		S	0.41
		Na	0.90
		Fe	50.09
		Si	1.99
		Ni	24.59
		Cr	7.19
D2-4C-1	1.0	C	5.94
		O	7.90
		S	0.32
		Na	1.43
		Fe	50.34
		Si	2.49
		Ni	22.82
		Cr	8.77
D2-4C-1	1.25	C	5.72
		O	6.96
		S	0.42
		Na	1.48
		Fe	50.86
		Si	2.40
		Ni	23.10
		Cr	9.06

Figure F-10 (continued).

Atomic concentrations at selected depths for stainless steel bolt D2-4c, area 1.

<u>Bolt L.D.</u>	<u>Depth (min)</u>	<u>Element</u>	<u>Atomic Concentration (%)</u>
D2-4C-1	1.5	C	5.98
		O	6.39
		S	0.47
		Na	1.61
		Fe	49.86
		Si	2.61
		Ni	23.44
		Cr	9.64
D2-4C-1	1.75	C	5.70
		O	5.64
		S	0.33
		Na	1.57
		Fe	51.76
		Si	2.33
		Ni	23.23
		Cr	9.44
D2-4C-1	2.0	C	5.62
		O	5.69
		S	0.47
		Na	1.32
		Fe	52.00
		Si	1.61
		Ni	23.50
		Cr	9.79

Figure F-10 (continued). Atomic concentrations at selected depths for stainless steel bolt D2-4c, area 1.

<u>Bolt I.D.</u>	<u>Depth (min)</u>	<u>Element</u>	<u>Atomic Concentration (%)</u>
D2-4C-2	Surface	C	50.78
		O	17.35
		Ti	1.17
		Na	2.39
		Fe	13.63
		Si	6.79
		Ni	6.12
		Cr	1.78
D2-4C-2	0.25	C	14.25
		O	25.68
		Ti	2.04
		Na	2.22
		Fe	29.61
		Si	4.90
		Ni	14.71
		Cr	6.58
D2-4C-2	0.5	C	9.73
		O	8.58
		Ti	2.57
		Na	1.62
		Fe	45.93
		Si	2.25
		Ni	22.00
		Cr	7.32

Figure F-11. Atomic concentrations at selected depths for stainless steel bolt D2-4c, area 2.

Bolt L.D.	Depth (min)	<u>Element</u>	<u>Atomic Concentration (%)</u>
D2-4C-2	0.75	C	6.48
		O	3.83
		Ti	3.12
		Na	1.10
		Fe	51.96
		Si	1.77
		Ni	23.16
		Cr	8.58
D2-4C-2	1.0	C	5.52
		O	2.48
		Ti	2.98
		Na	1.51
		Fe	53.82
		Si	1.75
		Ni	22.57
		Cr	9.37
D2-4C-2	1.25	C	5.36
		O	2.98
		Ti	1.88
		Na	1.49
		Fe	54.71
		Si	1.92
		Ni	21.60
		Cr	10.07

Figure F-11 (continued).

Atomic concentrations at selected depths for stainless steel
bolt D2-4c, area 2.

<u>Bolt L.D.</u>	<u>Depth (min)</u>	<u>Element</u>	<u>Atomic Concentration (%)</u>
D2-4C-2	1.5	C	4.34
		O	2.38
		Ti	2.58
		Na	1.40
		Fe	54.51
		Si	1.90
		Ni	21.61
		Cr	11.28
D2-4C-2	1.75	C	4.78
		O	2.73
		Ti	2.52
		Na	1.13
		Fe	54.50
		Si	1.67
		Ni	21.87
		Cr	10.80
D2-4C-2	2.0	C	4.24
		O	1.70
		Ti	2.41
		Na	1.49
		Fe	54.23
		Si	2.17
		Ni	22.91
		Cr	10.85

Figure F-11 (continued). Atomic concentrations at selected depths for stainless steel bolt D2-4c, area 2.

Bolt L.D.	Depth (min)	Element	Atomic Concentration (%)
D5-8C-1	Surface	C	44.61
		O	19.12
		Ti	2.39
		Na	4.80
		Fe	10.95
		Si	9.69
		Ni	6.50
		Cr	1.95
D5-8C-1	0.25	C	14.68
		O	19.10
		Ti	2.77
		Na	2.11
		Fe	28.53
		Si	9.22
		Ni	17.37
		Cr	6.22
D5-8C-1	0.5	C	11.13
		O	10.11
		Ti	1.87
		Na	1.81
		Fe	41.61
		Si	4.55
		Ni	22.50
		Cr	6.44

Figure F-12. Atomic concentrations at selected depths for stainless steel bolt D5-8c, area 1.

<u>Bolt L.D.</u>	<u>Depth (min)</u>	<u>Element</u>	<u>Atomic Concentration (%)</u>
D5-8C-1	0.75	C	9.57
		O	6.97
		Ti	1.48
		Na	2.07
		Fe	48.27
		Si	2.76
		Ni	22.13
		Cr	6.77
D5-8C-1	1.0	C	7.90
		O	5.07
		Ti	2.22
		Na	1.24
		Fe	52.28
		Si	3.33
		Ni	21.62
		Cr	6.35
D5-8C-1	1.25	C	6.55
		O	4.63
		Ti	1.98
		Na	1.91
		Fe	51.95
		Si	2.43
		Ni	23.12
		Cr	7.44

Figure F-12 (continued). Atomic concentrations at selected depths for stainless steel bolt D5-8c, area 1.

Bolt L.D.	Depth (min)	Element	Atomic Concentration (%)
D5-8C-1	1.5	C	7.52
		O	4.04
		Ti	2.22
		Na	1.79
		Fe	50.66
		Si	2.70
		Ni	22.96
		Cr	8.11
D5-8C-1	1.75	C	5.18
		O	4.79
		Ti	2.10
		Na	1.27
		Fe	52.41
		Si	2.43
		Ni	23.42
		Cr	8.40
D5-8C-1	2.0	C	5.92
		O	4.14
		Ti	2.02
		Na	1.63
		Fe	53.08
		Si	2.17
		Ni	23.18
		Cr	7.88

Figure F-12 (continued).

Atomic concentrations at selected depths for stainless steel bolt D5-8c, area 1.

Bolt I.D.	Depth (min)	Element	Atomic Concentration (%)
D5-8C-2	Surface	C	67.83
		O	10.12
		Ti	2.01
		Na	2.84
		Fe	4.95
		Si	10.05
		Ni	1.27
D5-8C-2	0.25	C	51.72
		O	16.32
		Ti	2.25
		Na	3.62
		Fe	7.93
		Si	13.43
		Ni	3.25
		Cr	1.49
D5-8C-2	0.5	C	39.04
		O	18.85
		Ti	2.09
		Na	2.61
		Fe	13.10
		Si	15.64
		Ni	5.48
		Cr	3.19

Figure F-13. Atomic concentrations at selected depths for stainless steel bolt D5-8c, area 2.

Bolt L.D.	Depth (min)	Element	Atomic Concentration (%)
D5-8C-2	0.75	C	31.40
		O	17.62
		Ti	2.88
		Na	3.27
		Fe	19.28
		Si	13.10
		Ni	8.92
		Cr	3.52
D5-8C-2	1.0	C	26.87
		O	16.13
		Ti	3.18
		Na	3.19
		Fe	24.00
		Si	10.45
		Ni	11.05
		Cr	5.14
D5-8C-2	1.25	C	24.59
		O	13.83
		Ti	3.09
		Na	2.99
		Fe	29.44
		Si	8.75
		Ni	11.71
		Cr	5.60

Figure F-13 (continued). Atomic concentrations at selected depths for stainless steel bolt D5-8c, area 2.

<u>Bolt L.D.</u>	<u>Depth (min)</u>	<u>Element</u>	<u>Atomic Concentration (%)</u>
D5-8C-2	1.5	C	22.01
		O	12.43
		Ti	2.29
		Na	1.82
		Fe	32.51
		Si	7.92
		Ni	13.79
		Cr	7.23
D5-8C-2	1.75	C	21.98
		O	10.86
		Ti	2.53
		Na	1.48
		Fe	35.20
		Si	6.03
		Ni	14.70
		Cr	7.22
D5-8C-2	2.0	C	18.93
		O	10.33
		Ti	2.71
		Na	1.92
		Fe	38.56
		Si	5.19
		Ni	15.42
		Cr	6.95

Figure F-13 (continued). Atomic concentrations at selected depths for stainless steel bolt D5-8c, area 2.

Bolt L.D.	Depth (min)	Element	Atomic Concentration (%)
D5-8C-2	2.25	C	23.03
		O	9.99
		Ti	3.47
		Na	1.81
		Fe	35.05
		Si	6.83
		Ni	14.62
		Cr	5.21
D5-8C-2	2.5	C	19.44
		O	10.84
		Ti	2.62
		Na	1.94
		Fe	37.85
		Si	6.43
		Ni	14.40
		Cr	6.48
D5-8C-2	2.75	C	19.06
		O	9.16
		Ti	3.12
		Na	3.98
		Fe	36.64
		Si	5.10
		Ni	15.59
		Cr	7.36

Figure F-13 (continued). Atomic concentrations at selected depths for stainless steel bolt D5-8c, area 2.

<u>Bolt L.D.</u>	<u>Depth (min)</u>	<u>Element</u>	<u>Atomic Concentration (%)</u>
D5-8C-2	3.0	C	17.52
		O	9.15
		Ti	2.93
		Na	2.06
		Fe	39.57
		Si	6.02
		Ni	15.56
		Cr	7.19
D5-8C-2	3.25	C	17.92
		O	10.10
		Ti	3.06
		Na	2.27
		Fe	37.63
		Si	5.35
		Ni	16.07
		Cr	7.60
D5-8C-2	3.5	C	15.70
		O	8.34
		Ti	3.96
		Na	1.91
		Fe	41.38
		Si	5.77
		Ni	16.07
		Cr	6.86

Figure F-13 (continued). Atomic concentrations at selected depths for stainless steel bolt D5-8c, area 2.

Bolt L.D.	Depth (min)	Element	Atomic Concentration (%)
D5-8C-2	3.75	C	14.65
		O	8.16
		Ti	2.83
		Na	1.82
		Fe	41.51
		Si	5.46
		Ni	17.01
		Cr	8.55
D5-8C-2	4.0	C	14.40
		O	8.17
		Ti	3.54
		Na	1.87
		Fe	41.56
		Si	5.14
		Ni	16.87
		Cr	8.44
D5-8C-2	5.0	C	12.23
		O	7.48
		Ti	3.62
		Na	1.82
		Fe	43.89
		Si	4.46
		Ni	18.50
		Cr	7.99

Figure F-13 (continued). Atomic concentrations at selected depths for stainless steel bolt D5-8c, area 2.

<u>Bolt L.D.</u>	<u>Depth (min)</u>	<u>Element</u>	<u>Atomic Concentration (%)</u>
D5-8C-2	6.0	C	11.00
		O	6.89
		Ti	3.00
		Na	1.89
		Fe	45.81
		Si	3.94
		Ni	18.79
		Cr	8.72
D5-8C-2	7.0	C	9.49
		O	5.31
		Ti	3.27
		Na	1.35
		Fe	48.12
		Si	3.44
		Ni	20.01
		Cr	9.02
D5-8C-2	8.0	C	8.79
		O	4.82
		Ti	4.16
		Na	1.46
		Fe	48.51
		Si	2.40
		Ni	19.93
		Cr	9.93

Figure F-13 (continued).

Atomic concentrations at selected depths for stainless steel
bolt D5-8c, area 2.

<u>Bolt</u> <u>L.D.</u>	<u>Depth</u> <u>(min)</u>	<u>Element</u>	<u>Atomic</u> <u>Concentration (%)</u>
D5-8C-2	9.0	C	8.75
		O	4.73
		Ti	2.72
		Na	1.23
		Fe	49.36
		Si	2.52
		Ni	20.68
		Cr	10.00
D5-8C-2	10.0	C	8.33
		O	4.20
		Ti	3.50
		Na	1.12
		Fe	49.78
		Si	3.28
		Ni	20.42
		Cr	9.38

Figure F-13 (continued). Atomic concentrations at selected depths for stainless steel bolt D5-8c, area 2.

<u>Bolt L.D.</u>	<u>Depth (min)</u>	<u>Element</u>	<u>Atomic Concentration (%)</u>
D7-7a	Surface	C	15.37
		O	17.99
		Ca	4.03
		N	3.43
		Fe	21.61
		Si	16.29
		Ni	11.01
		Mg	3.20
		Al	7.07
D7-7a	0.25	C	8.61
		O	15.58
		Ca	5.77
		N	3.26
		Fe	33.19
		Si	8.82
		Ni	16.58
		Mg	2.15
		Al	6.03
D7-7a	0.5	C	6.95
		O	6.59
		Ca	4.07
		N	3.29
		Fe	46.75
		Si	5.30
		Ni	20.31
		Mg	1.82
		Al	4.92

Figure F-14. Atomic concentrations at selected depths for stainless steel bolt D7-7a.

Bolt L.D.	Depth (min)	Element	Atomic Concentration (%)
D7-7a	0.75	C	6.36
		O	2.84
		Ca	1.68
		N	2.92
		Fe	55.56
		Si	2.73
		Ni	23.14
		Mg	1.79
		Al	2.98
D7-7a	1.0	C	6.07
		O	2.25
		Ca	1.42
		N	2.68
		Fe	57.29
		Si	1.73
		Ni	23.92
		Mg	1.53
		Al	3.12
D7-7a	1.25	C	6.14
		O	1.47
		Ca	1.42
		N	3.10
		Fe	56.65
		Si	1.28
		Ni	23.93
		Mg	1.65
		Al	4.35

Figure F-14 (continued). Atomic concentrations at selected depths for stainless steel bolt D7-7a.

Bolt L.D.	Depth (min)	Element	Atomic Concentration (%)
D7-7a	1.5	C	4.17
		O	0.82
		Ca	1.17
		N	3.10
		Fe	58.24
		Si	1.38
		Ni	24.69
		Mg	1.72
		Al	4.71
D7-7a	1.75	C	5.03
		O	0.56
		Ca	1.18
		N	3.18
		Fe	58.63
		Si	1.19
		Ni	24.46
		Mg	2.90
		Al	2.88
D7-7a	2.0	C	3.43
		O	0.80
		Ca	0.68
		N	3.23
		Fe	59.15
		Si	1.48
		Ni	24.90
		Mg	1.87
		Al	4.47

Figure F-14 (continued). Atomic concentrations at selected depths for stainless steel bolt D7-7a.

<u>Bolt L.D.</u>	<u>Depth (min)</u>	<u>Element</u>	<u>Atomic Concentration (%)</u>
E9-4C	Surface	C	6.86
		O	21.70
		Ca	1.41
		Ti	2.49
		Fe	26.96
		Si	19.95
		Ni	15.41
		Cr	5.23
E9-4C	0.25	C	5.15
		O	16.96
		Ca	1.95
		Ti	2.38
		Fe	38.19
		Si	8.58
		Ni	18.16
		Cr	8.63
E9-4C	0.5	C	6.22
		O	6.26
		Ca	1.23
		Ti	1.97
		Fe	47.50
		Si	4.03
		Ni	22.52
		Cr	10.27

Figure F-15. Atomic concentrations at selected depths for stainless steel bolt E9-4c.

Bolt L.D.	Depth (min.)	Element	Atomic Concentration (%)
E9-4C	0.75	C	5.18
		O	3.32
		Ca	0.79
		Ti	1.83
		Fe	52.53
		Si	2.34
		Ni	23.26
		Cr	10.75
E9-4C	1.0	C	5.94
		O	1.77
		Ca	0.84
		Ti	2.73
		Fe	53.57
		Si	1.50
		Ni	22.97
		Cr	10.67
E9-4C	1.25	C	3.39
		O	1.74
		Ca	0.76
		Ti	2.29
		Fe	55.41
		Si	1.46
		Ni	24.36
		Cr	10.59

Figure F-15 (continued). Atomic concentrations at selected depths from stainless steel bolt E9-4c

Bolt L.D.	Depth (min)	Element	Atomic Concentration (%)
E9-4C	1.5	C	4.55
		O	1.52
		Ca	0.91
		Ti	2.38
		Fe	55.99
		Si	1.34
		Ni	22.99
		Cr	10.33
E9-4C	1.75	C	3.11
		O	1.23
		Ca	0.68
		Ti	3.16
		Fe	54.99
		Si	1.82
		Ni	23.55
		Cr	11.47
E9-4C	2.0	C	3.55
		O	1.19
		Ca	0.58
		Ti	2.21
		Fe	56.72
		Si	1.12
		Ni	23.54
		Cr	11.09

Figure F-15 (continued). Atomic concentrations at selected depths for stainless steel bolt E9-4c

<u>Bolt L.D.</u>	<u>Depth (min)</u>	<u>Element</u>	<u>Atomic Concentration (%)</u>
H11-7A	Surface	C	10.73
		O	26.30
		Ca	1.32
		Ti	2.51
		Fe	23.32
		Si	22.97
		Ni	8.08
		Cr	4.78
H11-7A	0.25	C	7.15
		O	20.04
		Ca	2.43
		Ti	1.88
		Fe	35.28
		Si	9.96
		Ni	15.36
		Cr	7.90
H11-7A	0.5	C	8.63
		O	9.85
		Ca	1.96
		Ti	2.29
		Fe	45.15
		Si	3.97
		Ni	18.47
		Cr	9.69

Figure F-16. Atomic concentrations at selected depths for stainless steel bolt H11-7a.

Bolt L.D.	Depth (min)	<u>Element</u>	<u>Atomic Concentration (%)</u>
H11-7A	0.75	C	7.44
		O	5.75
		Ca	1.31
		Ti	2.66
		Fe	50.52
		Si	2.79
		Ni	20.10
		Cr	9.43
H11-7A	1.0	C	6.63
		O	4.39
		Ca	1.33
		Ti	3.47
		Fe	52.01
		Si	2.23
		Ni	20.10
		Cr	9.84
H11-7A	1.25	C	5.59
		O	3.82
		Ca	1.13
		Ti	2.73
		Fe	54.81
		Si	2.18
		Ni	19.37
		Cr	10.37

Figure F-16 (continued).

Atomic concentrations at selected depths for stainless steel bolt H11-7a.

Bolt L.D.	Depth (min)	Element	Atomic Concentration (%)
H11-7A	1.5	C	5.41
		O	4.22
		Ca	1.22
		Ti	2.97
		Fe	54.01
		Si	2.41
		Ni	19.83
		Cr	9.93
H11-7A	1.75	C	5.90
		O	4.06
		Ca	1.05
		Ti	3.14
		Fe	53.36
		Si	2.26
		Ni	19.90
		Cr	10.32
H11-7A	2.0	C	5.43
		O	3.76
		Ca	1.28
		Ti	4.01
		Fe	54.02
		Si	2.37
		Ni	19.37
		Cr	9.76

Figure F-16 (continued).

Atomic concentrations at selected depths for stainless steel bolt H11-7a.

Appendix G

Results of high resolution ESCA on LDEF bolts from selected locations

The high resolution spectra shown in this appendix were obtained to identify the type and relative amounts of silicon containing compounds on exposed bolt surfaces from LDEF. High vacuum silicone grease rubbed onto a gold substrate was used as the source to establish the energy of the Si 2p peak in silicone based material. A 1000Å layered SiO₂ on a silicon wafer was used to establish the energy of the Si 2p peak for "inorganic" silicon containing compounds. For silica type ma and for silicones the peak width is 1.5eV. Bolts D3-2b, location 1, and F11-5a, appear from analysis of the spectra to contain only silica based material. The carbon 1s spectra were obtained as reference points to establish the true energies of the silicon peaks.

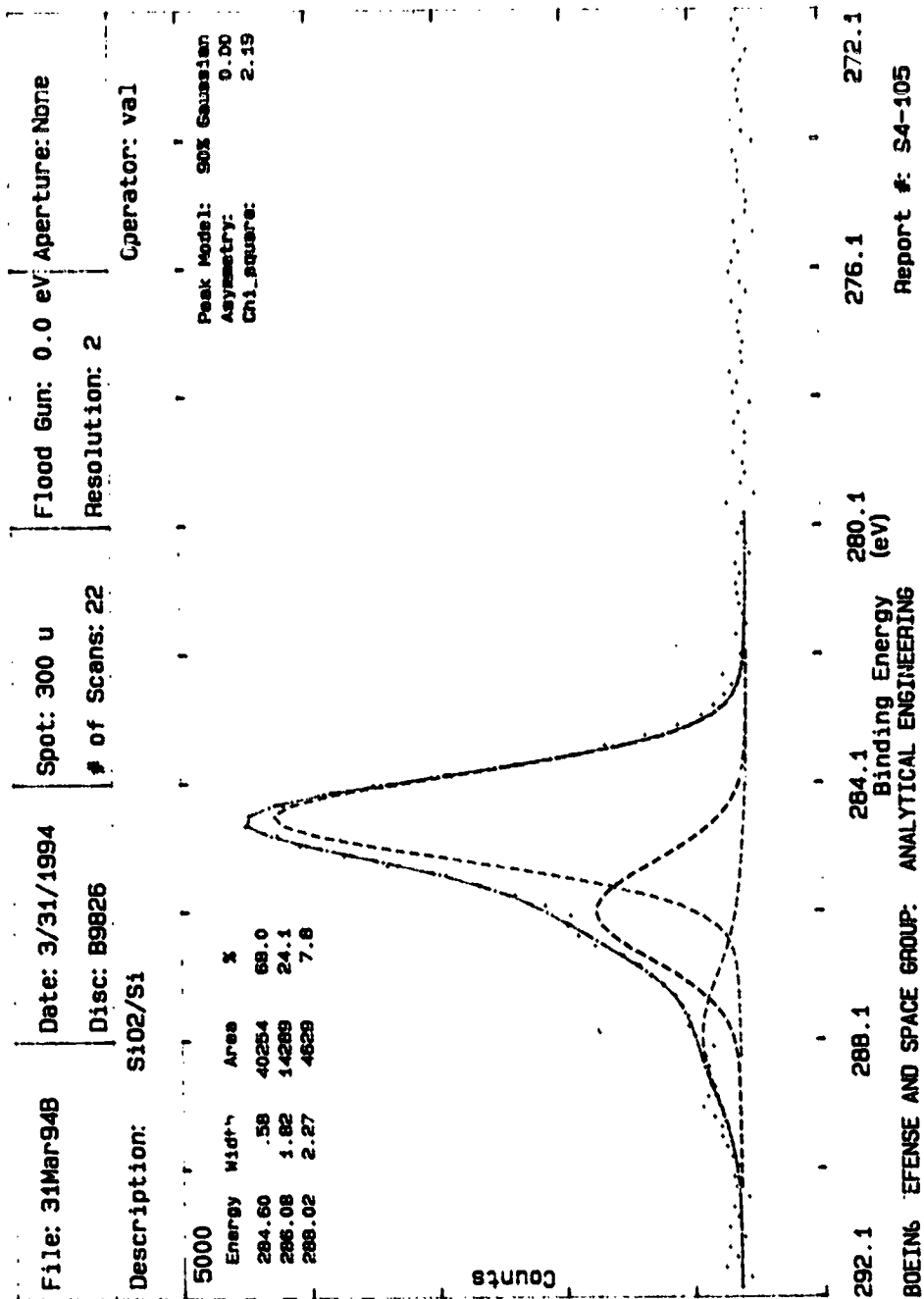
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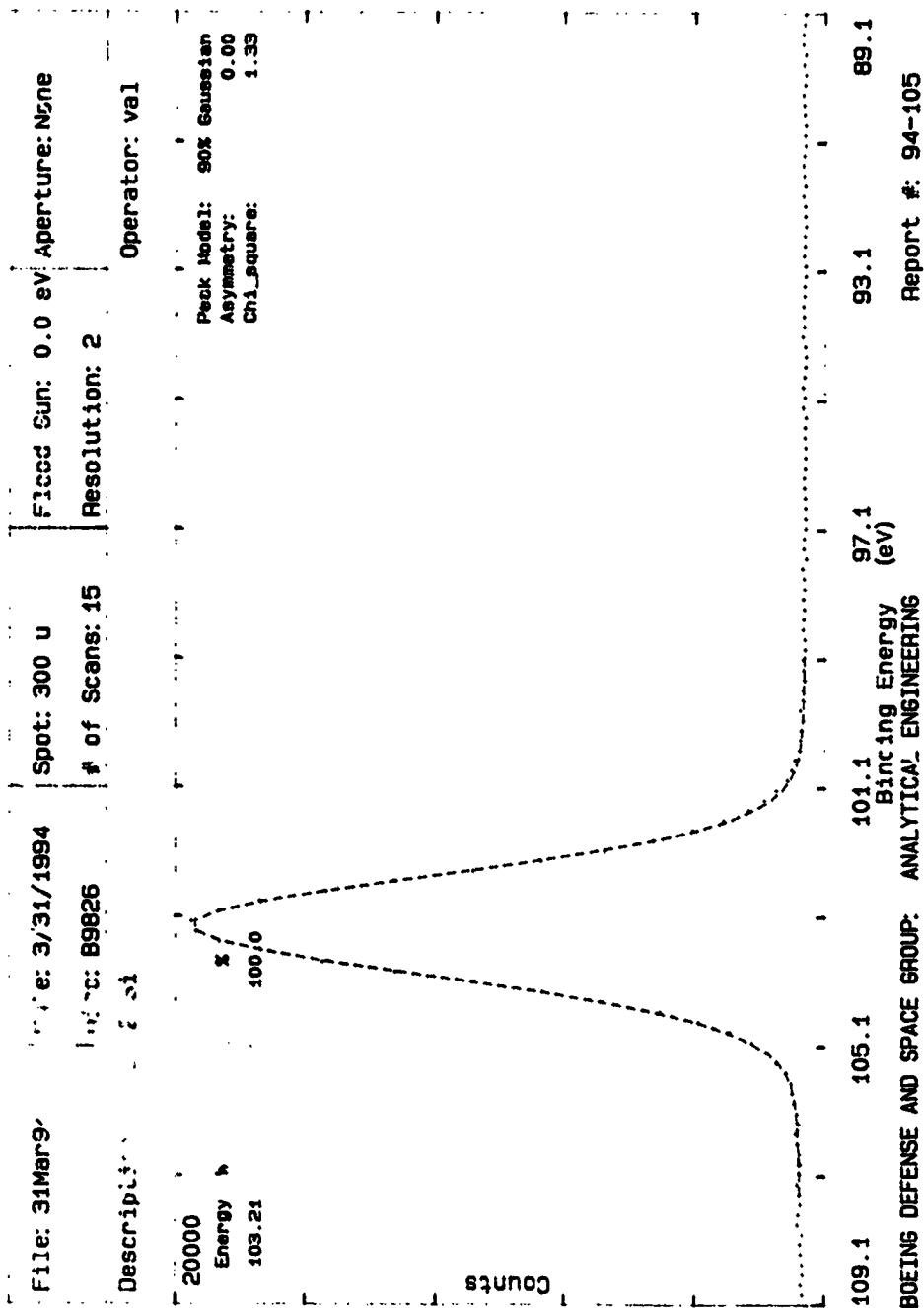
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Figure G-50.	Carbon 1s spectrum for bolt B3-6c, position 1.	G-55

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Figure G-51.	Silicon 2p spectrum for bolt B3-6c, position 1.	G-56
Figure G-52.	Carbon 1s spectrum for bolt B3-6c, position 2.	G-57
Figure G-53.	Silicon 2p spectrum for bolt B3-6c, position 2.	G-58



$\Delta be = -0.92 \text{ eV}$

Figure G-1. Carbon 1s spectrum for SiO₂/Si reference standard.



$Abc = -0.92 eV$

Figure G-2. Silicon 2p spectrum for SiO₂/Si reference standard.

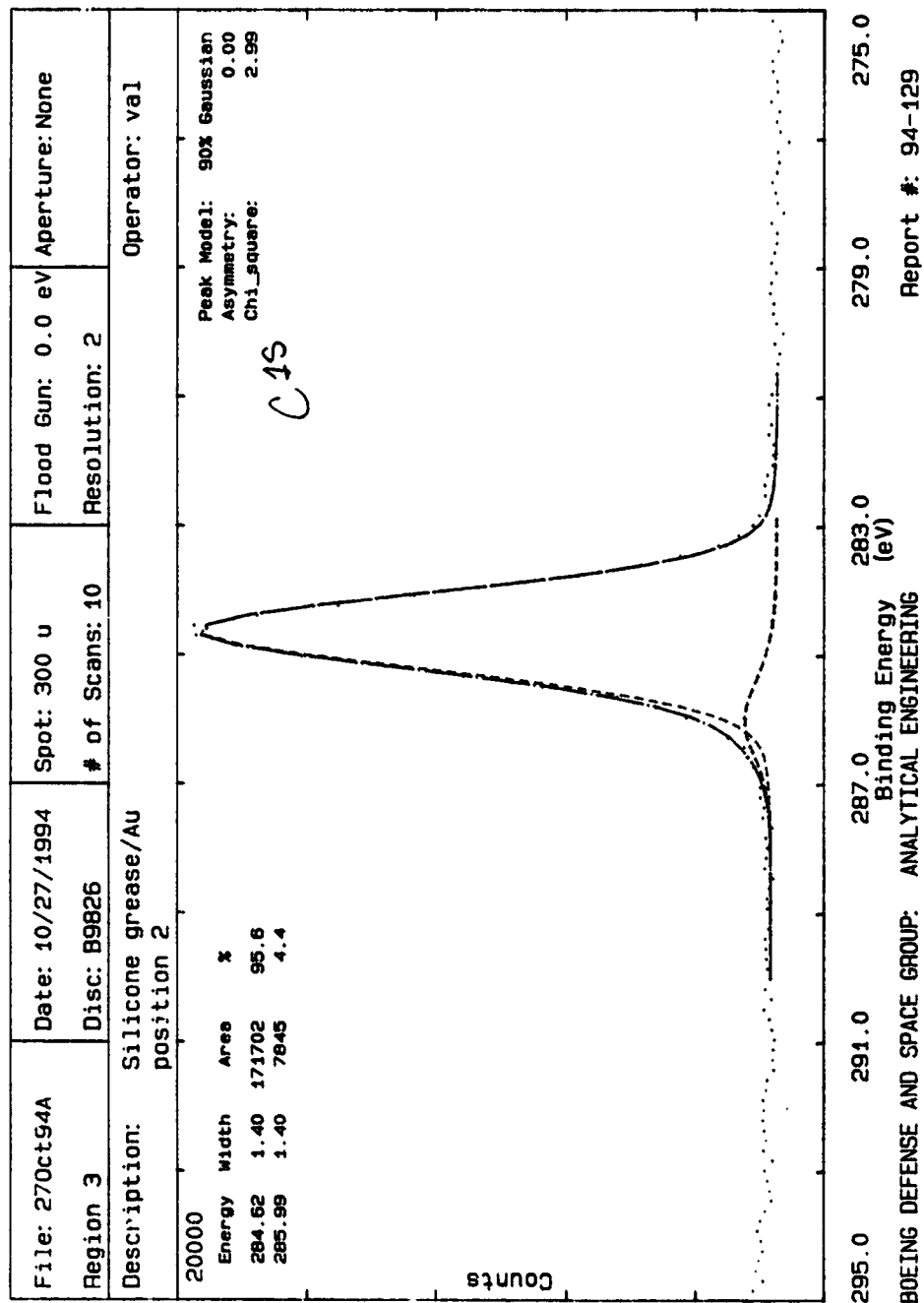


Figure G-3. Carbon 1s spectrum for silicone grease on the reference standard.

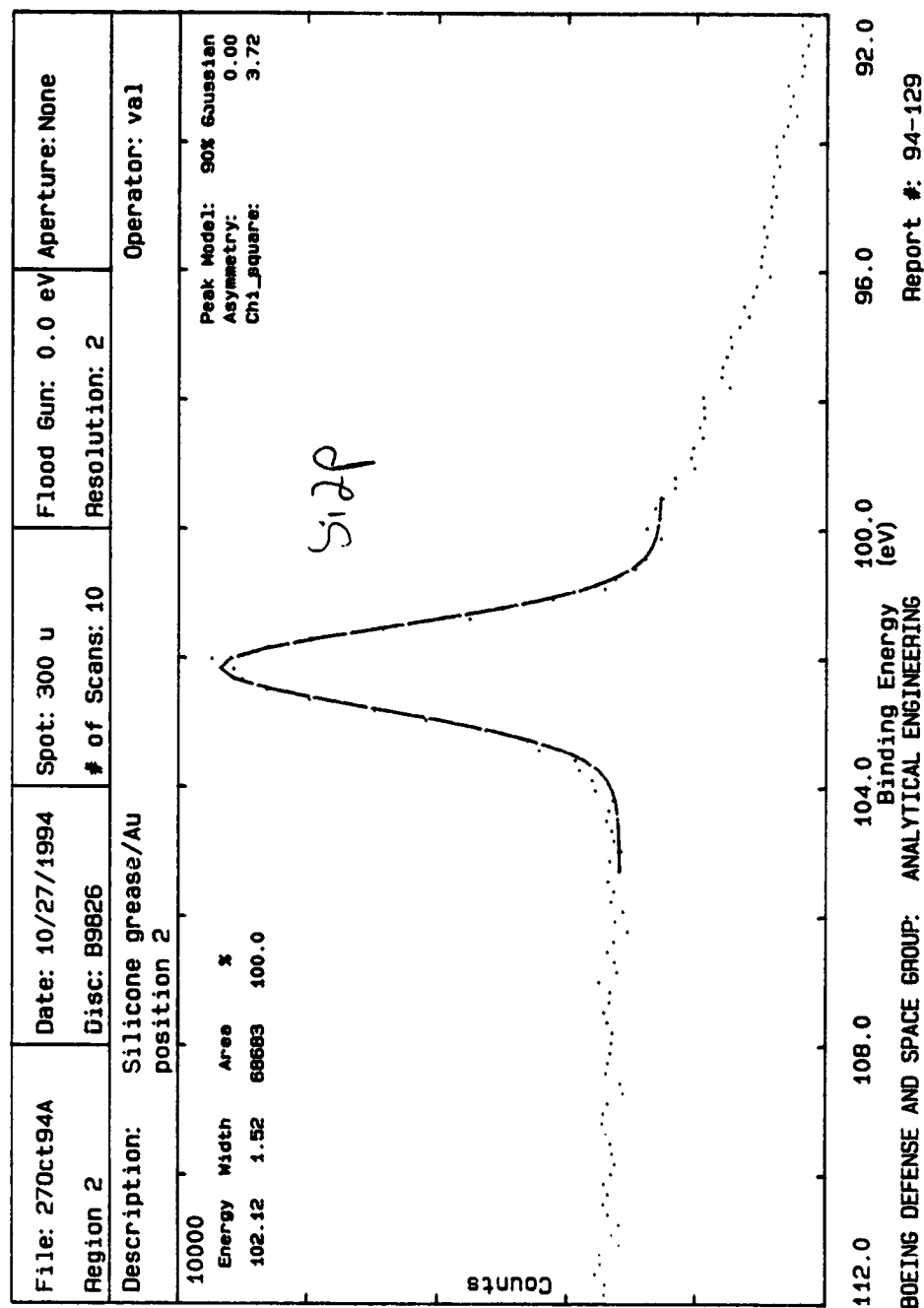


Figure G-4. Silicon 2p spectrum for silicone grease on the reference standard.

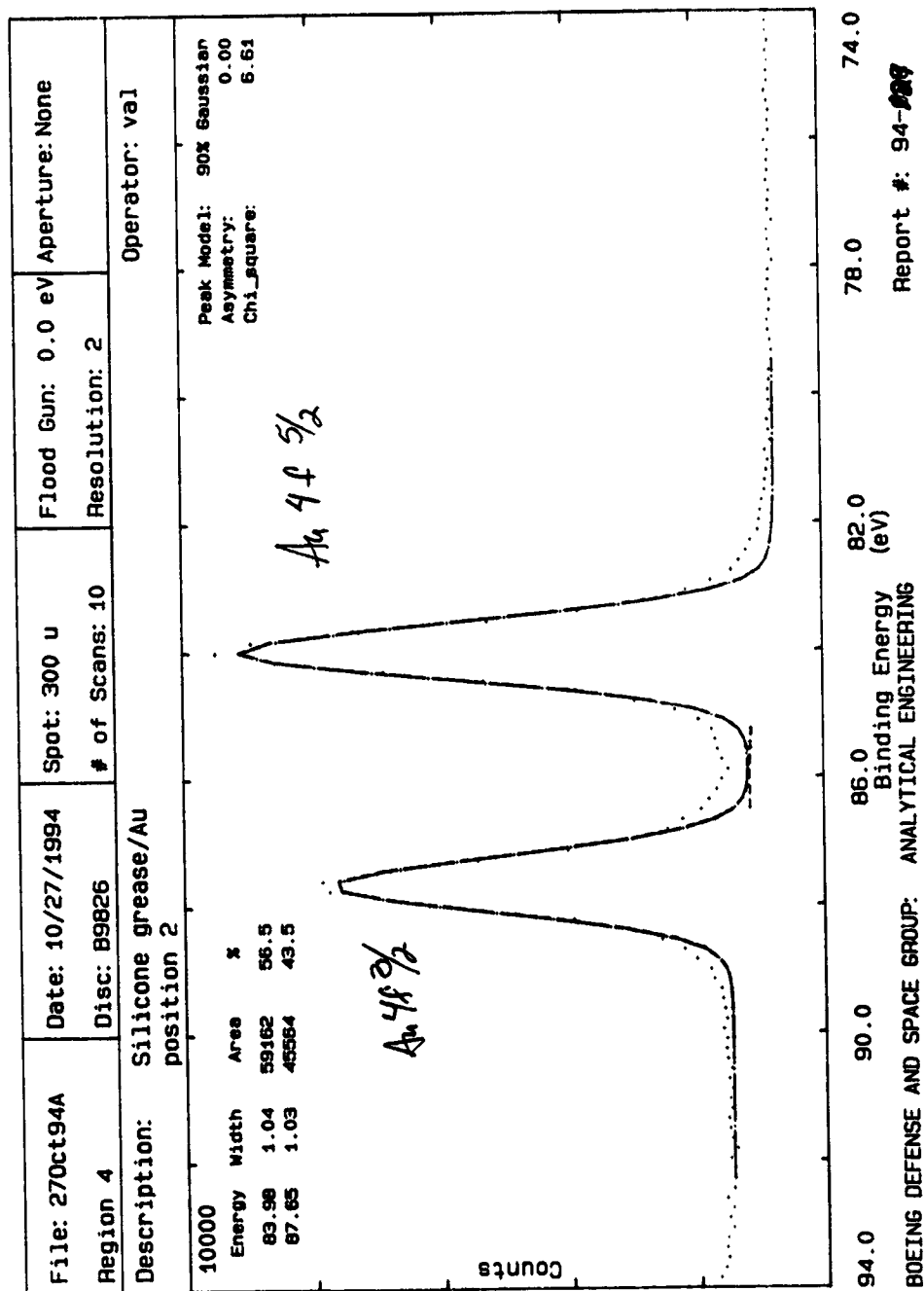
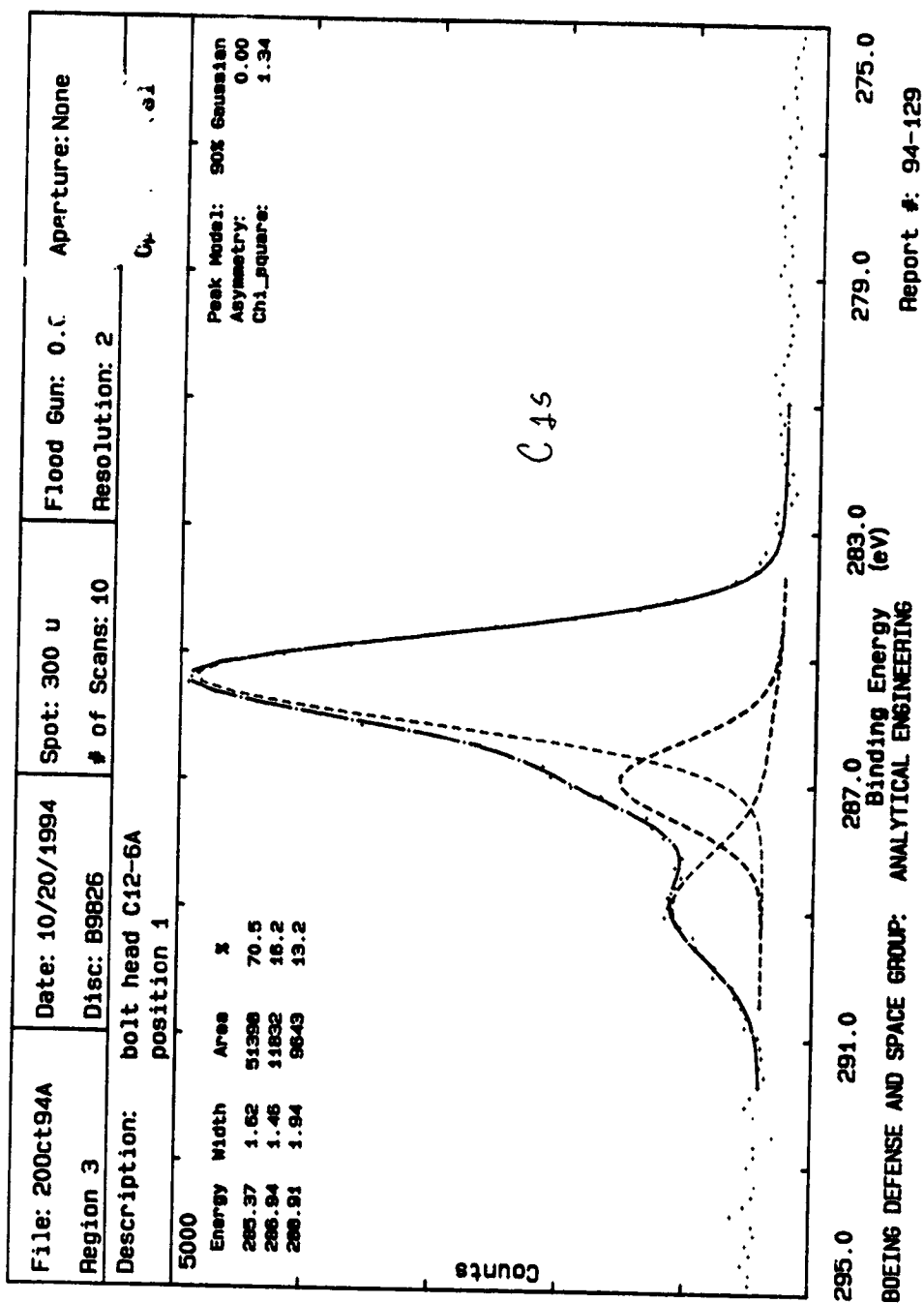


Figure G-5. Gold 4f spectrum from reference standard substrate.



$\Delta b_e = -0.8$

Figure G-6. Carbon 1s spectrum for bolt C12-6a, position 1.

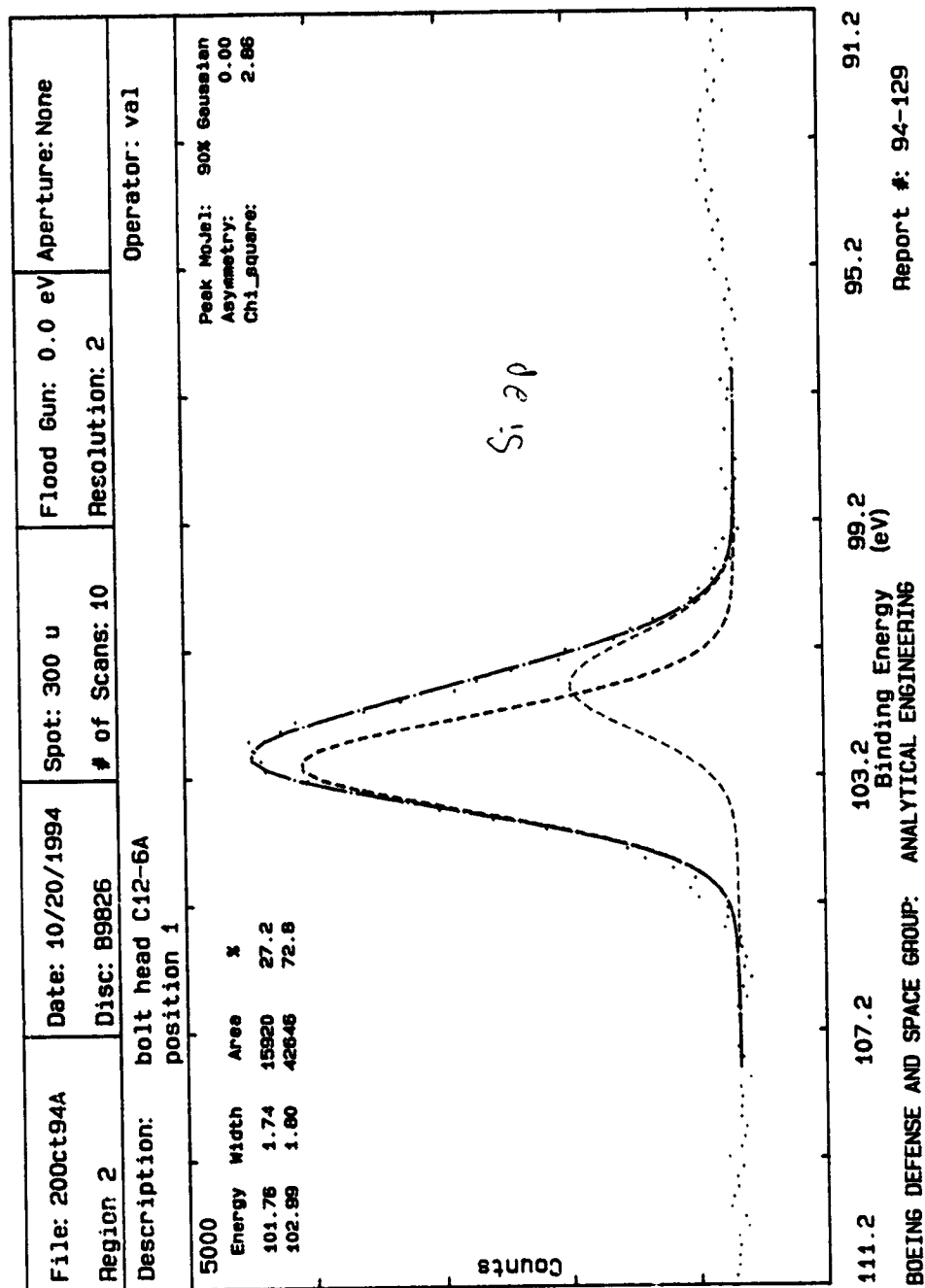
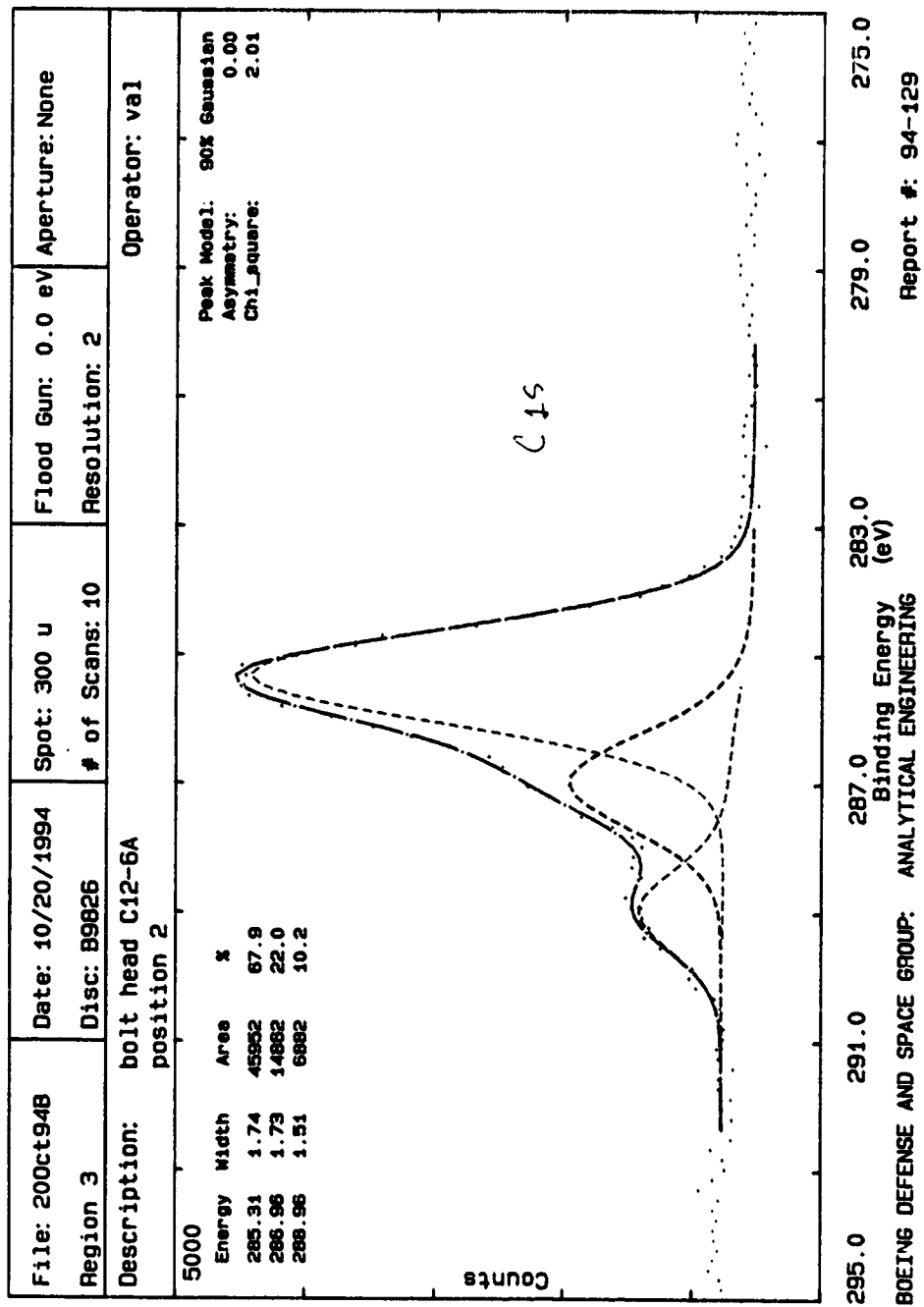


Figure G-7. Silicon 2p spectrum for bolt C12-6a, position 1.



abe = -0.7

Figure G-8. Carbon 1s spectrum for bolt C12-6a, position 2.

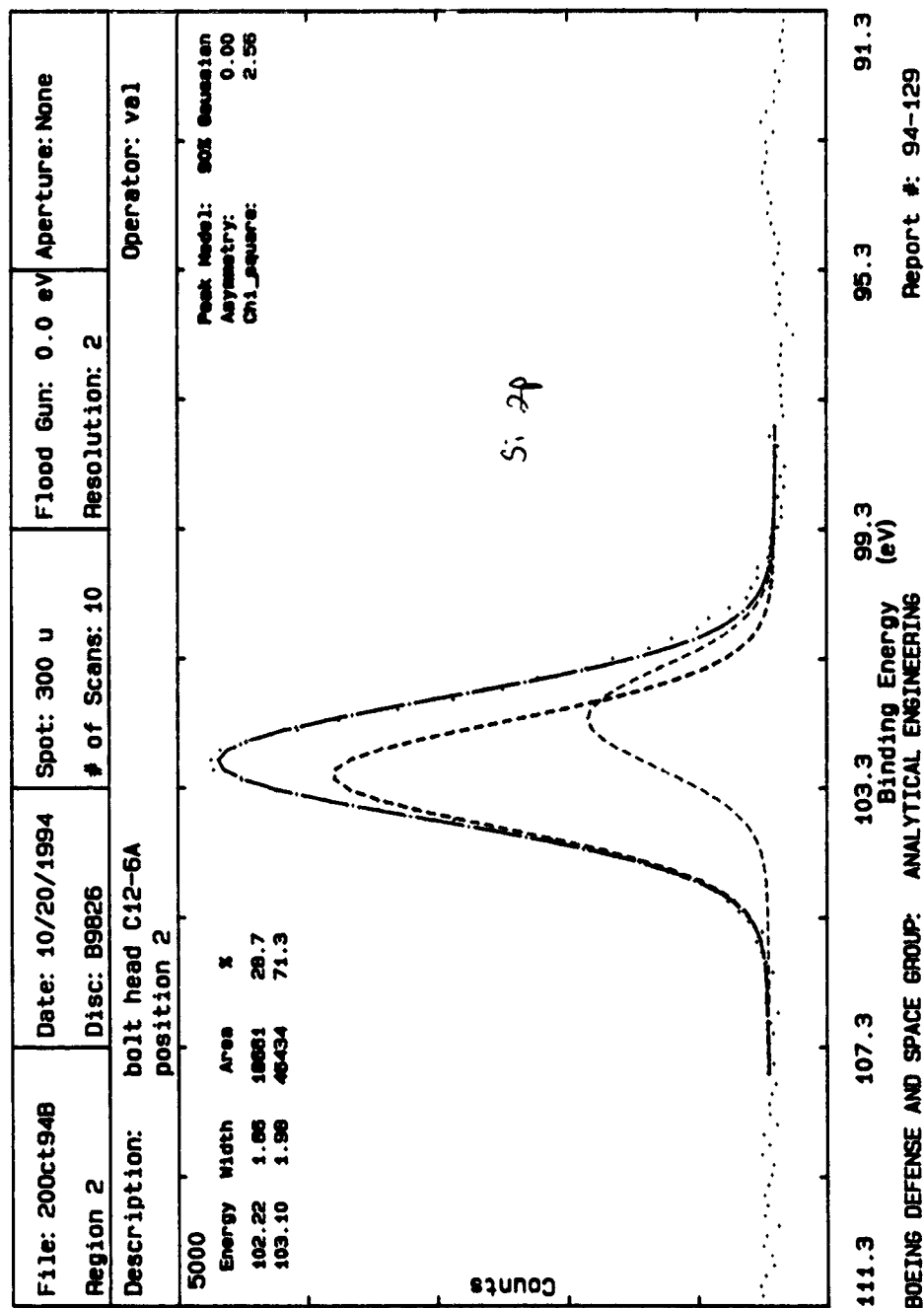
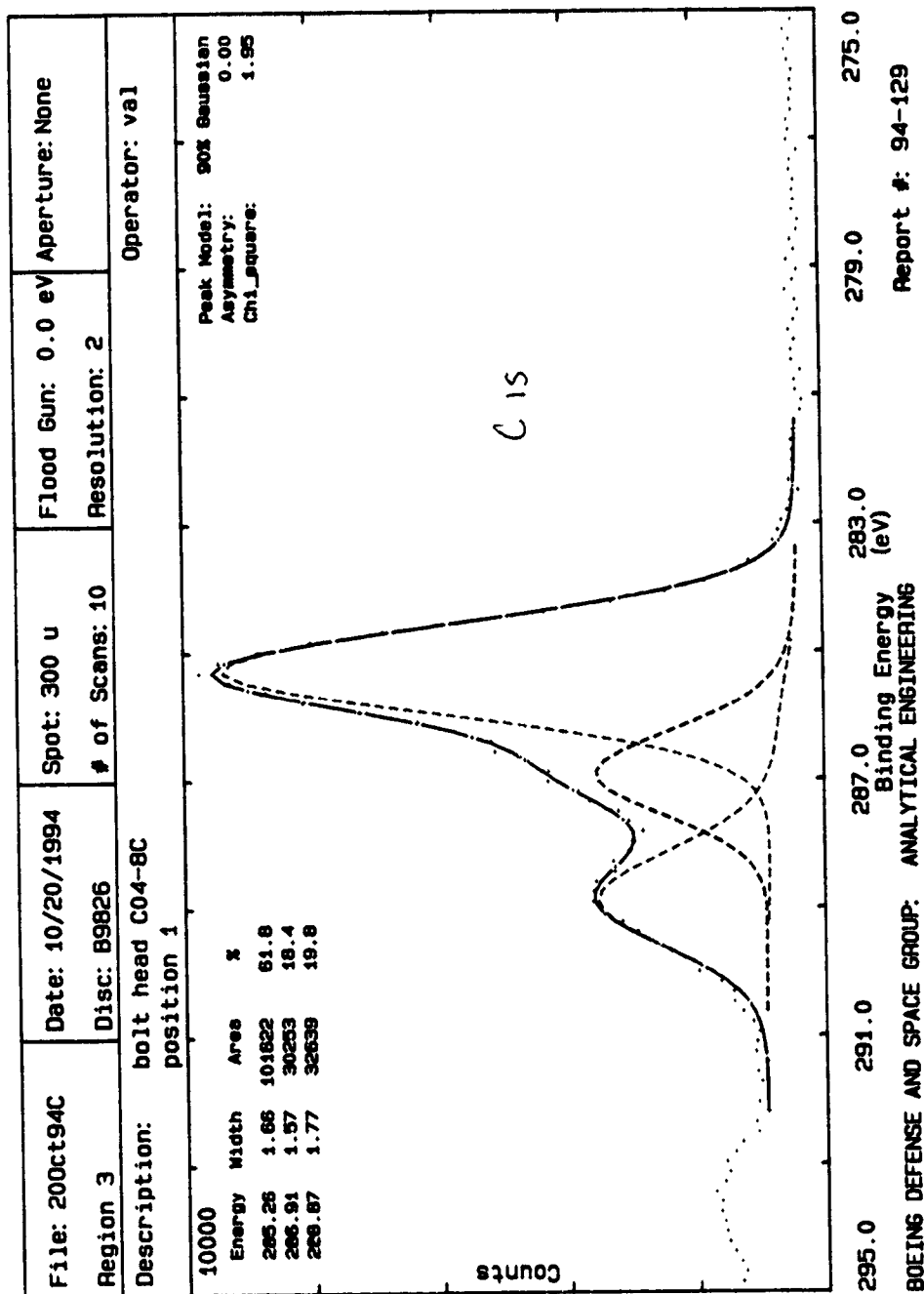


Figure G-9. Silicon 2p spectrum for bolt C12-6a, position 2.



Abd = 6.7

Figure G-10. Carbon 1s spectrum for bolt C4-8a, position 1.

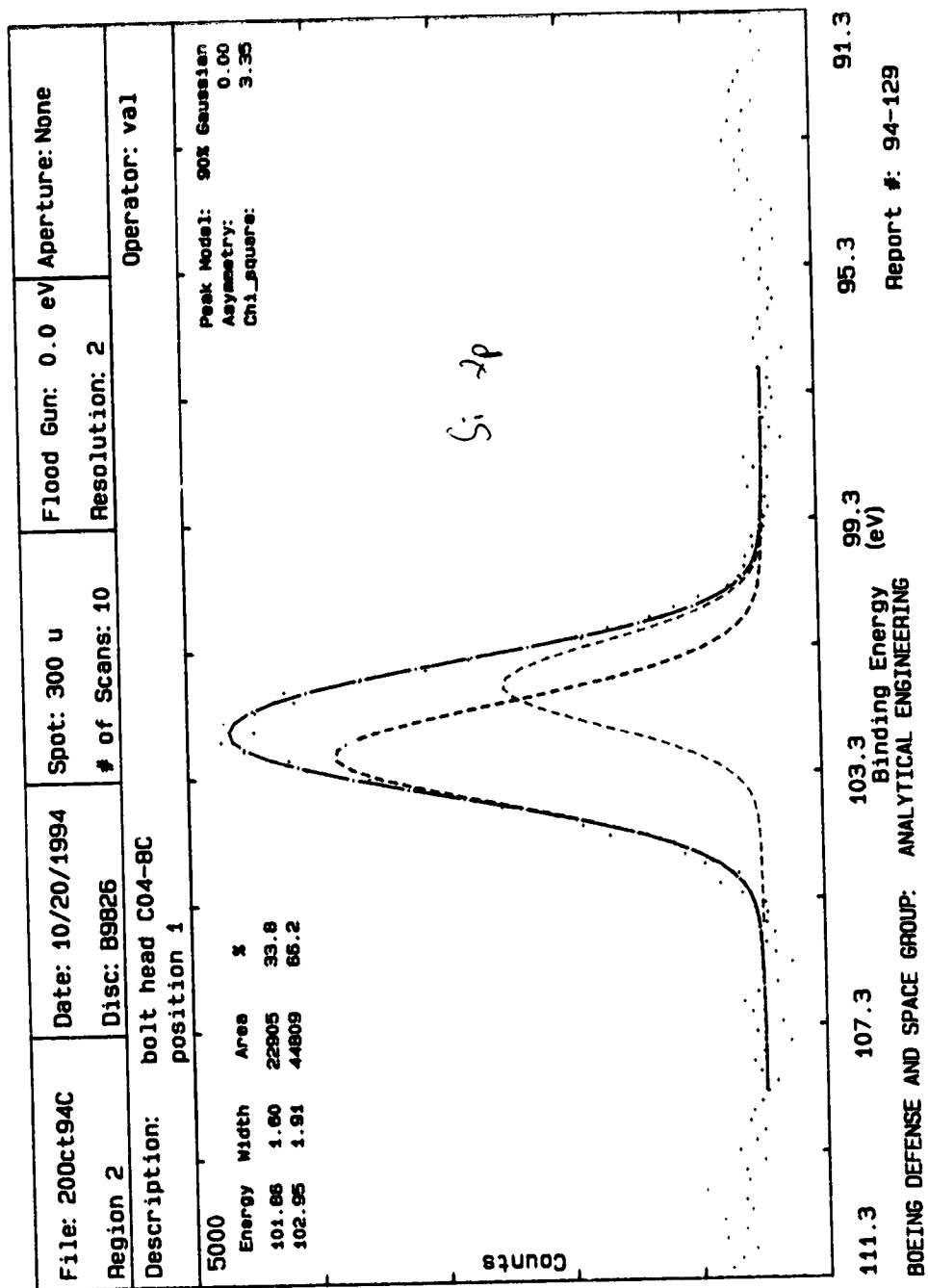


Figure G-11. Silicon 2p spectrum for bolt C4-8a, position 1.

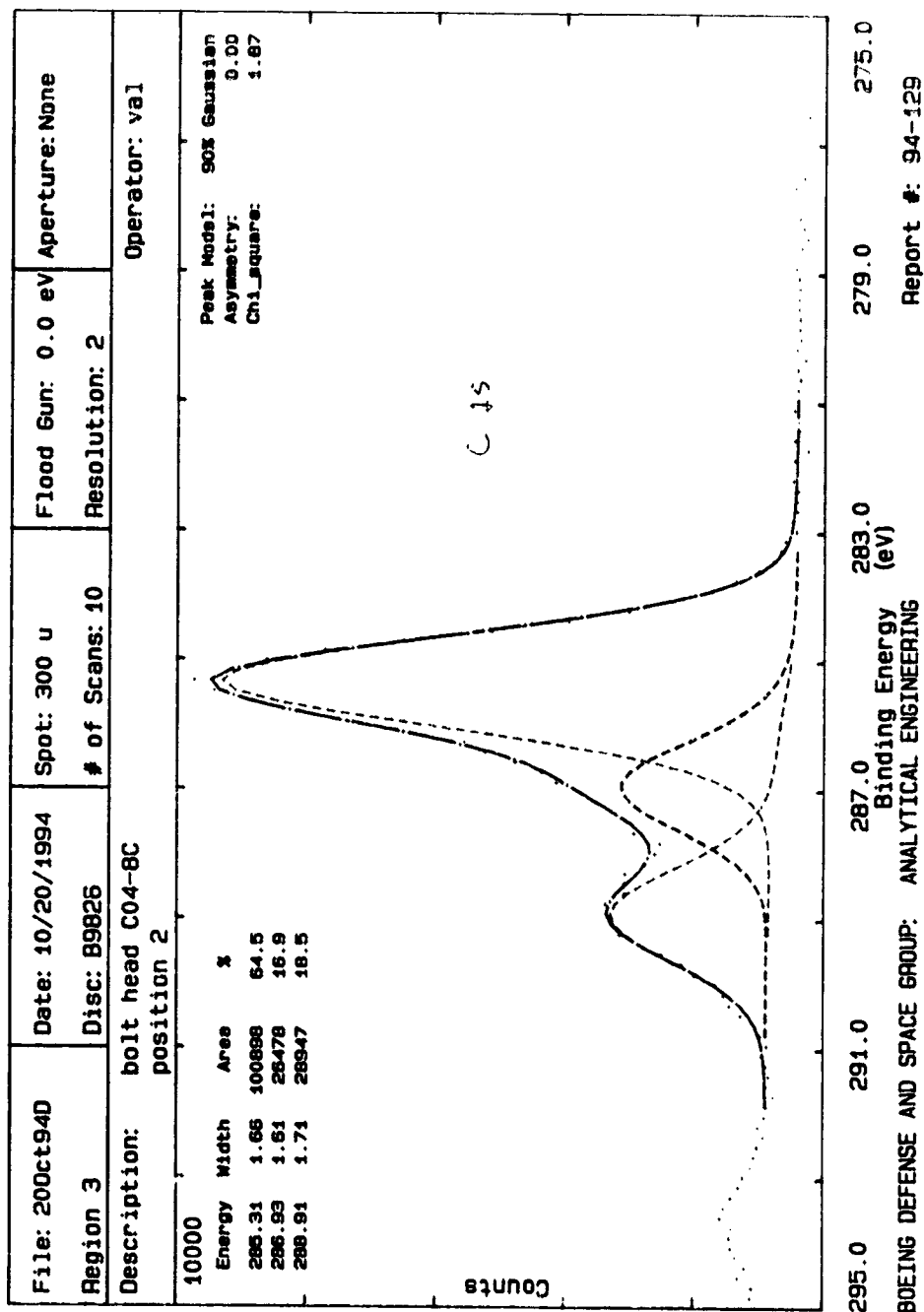
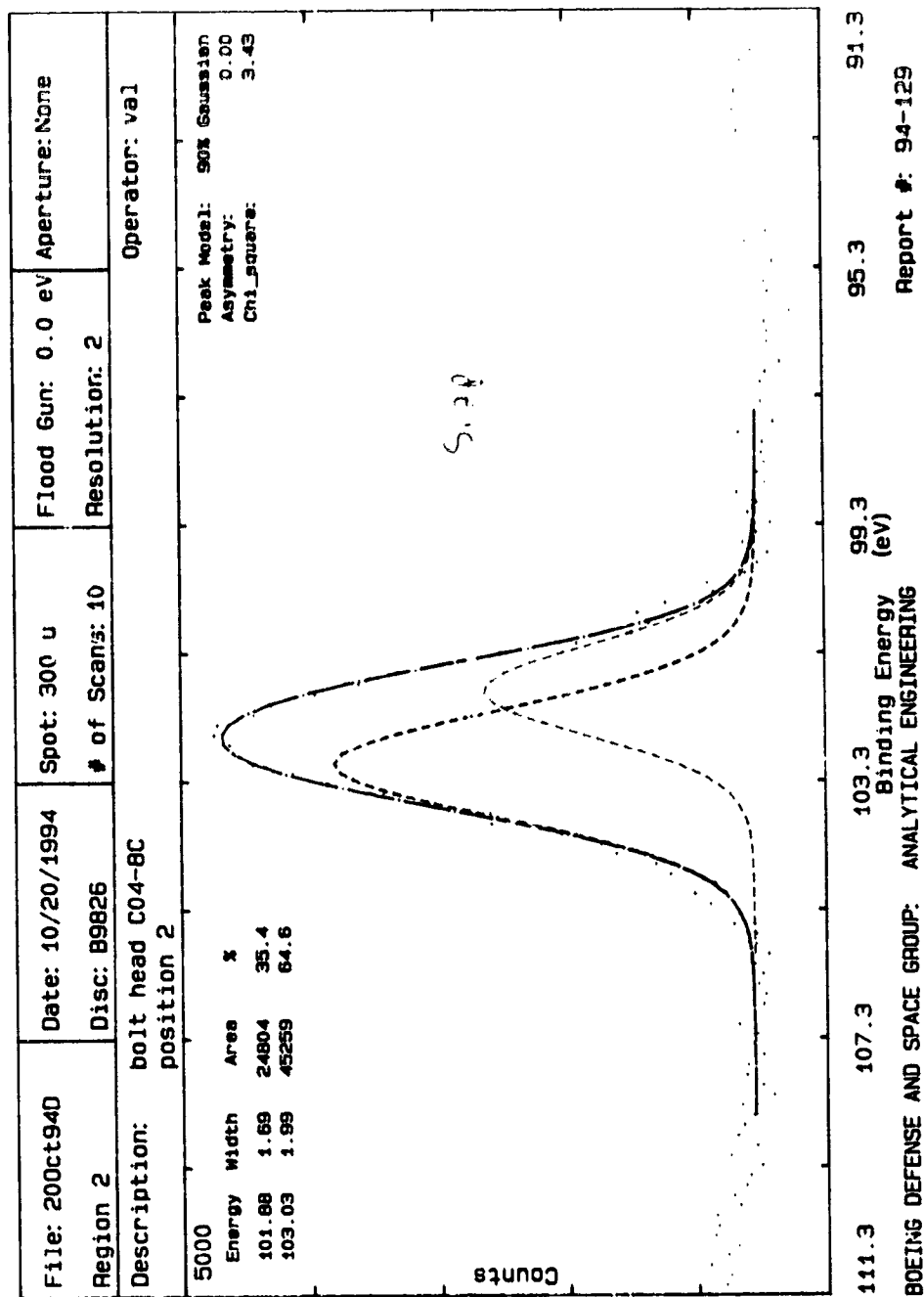
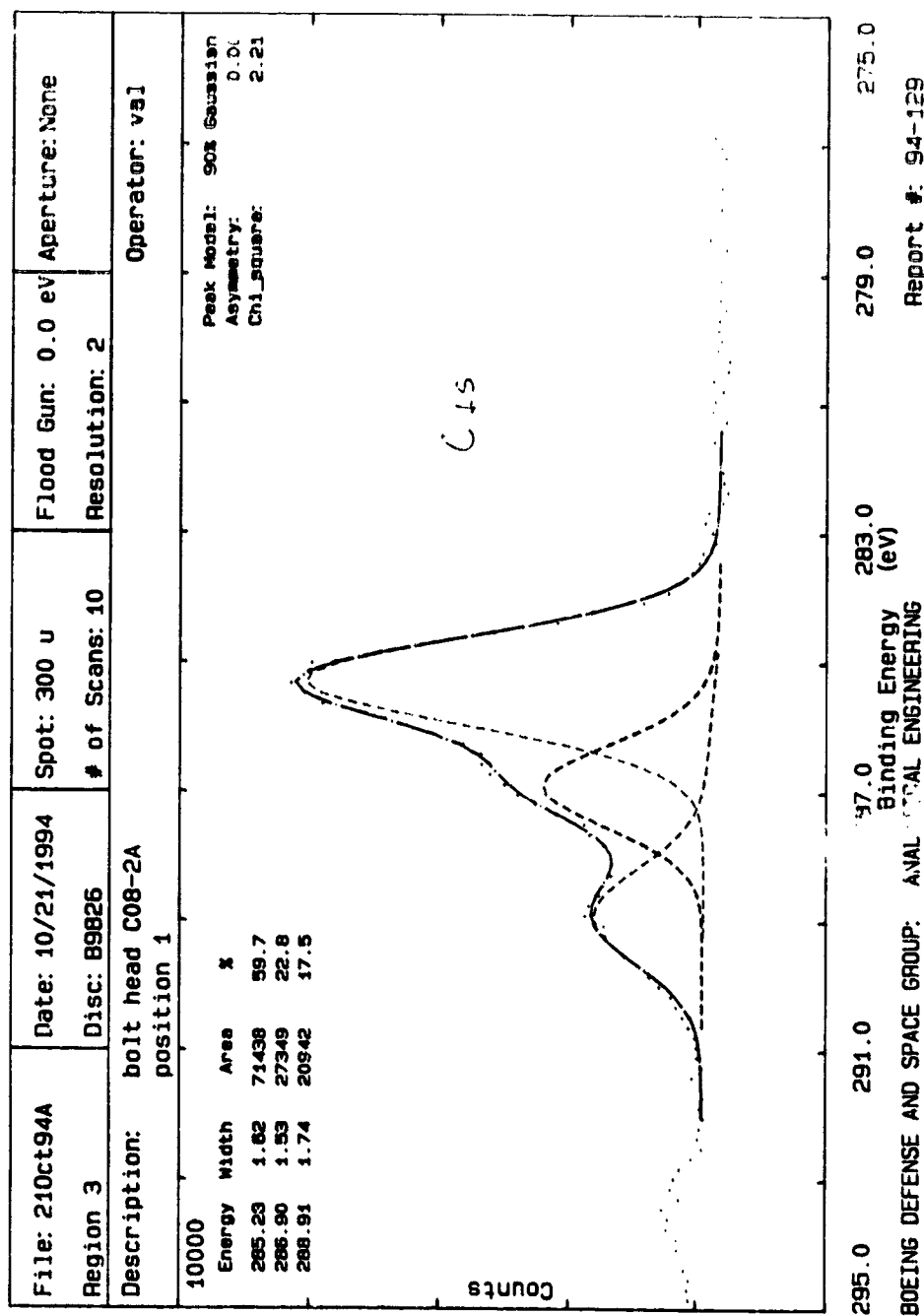


Figure G-12. Carbon 1s spectrum for bolt C4-8a, position 2.



$\Delta be = -0.7$

Figure G-13. Silicon 2p spectrum for bolt C4-8a, position 2.



$\Delta be = -0.7$

Figure G-14. Carbon 1s spectrum for bolt C8-2a, position 1.

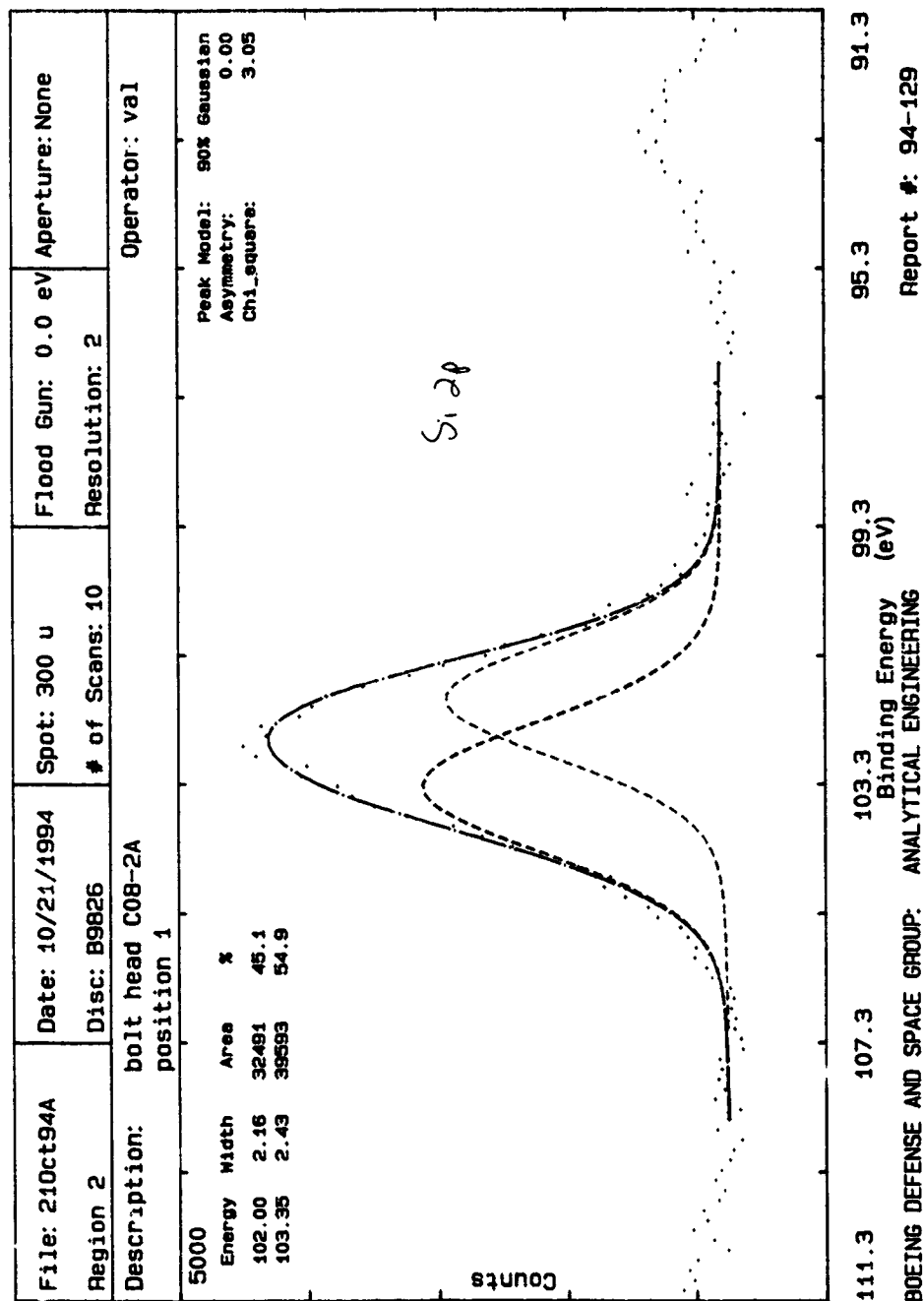


Figure G-15. Silicon 2p spectrum for bolt C8-2a, position 1.

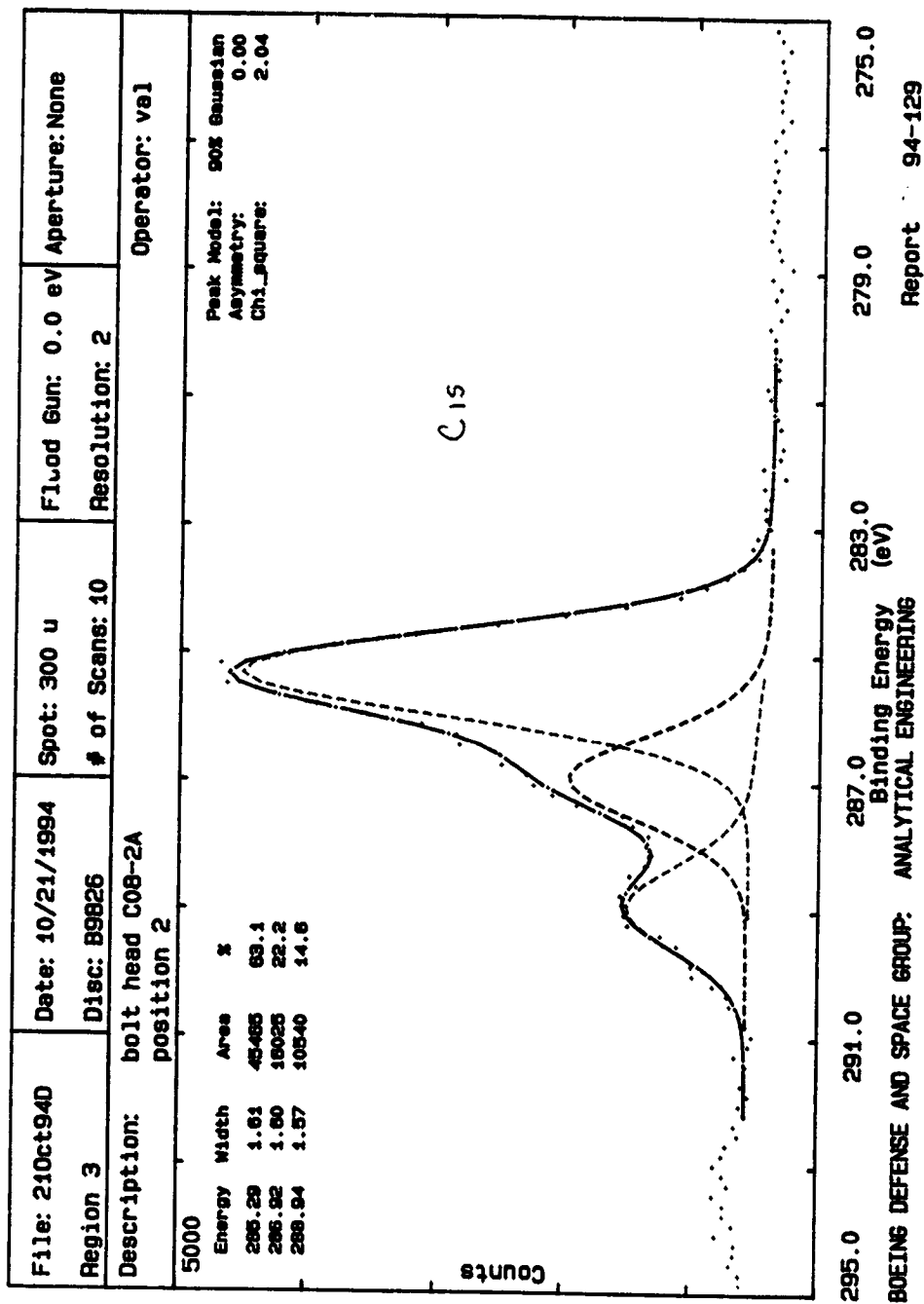
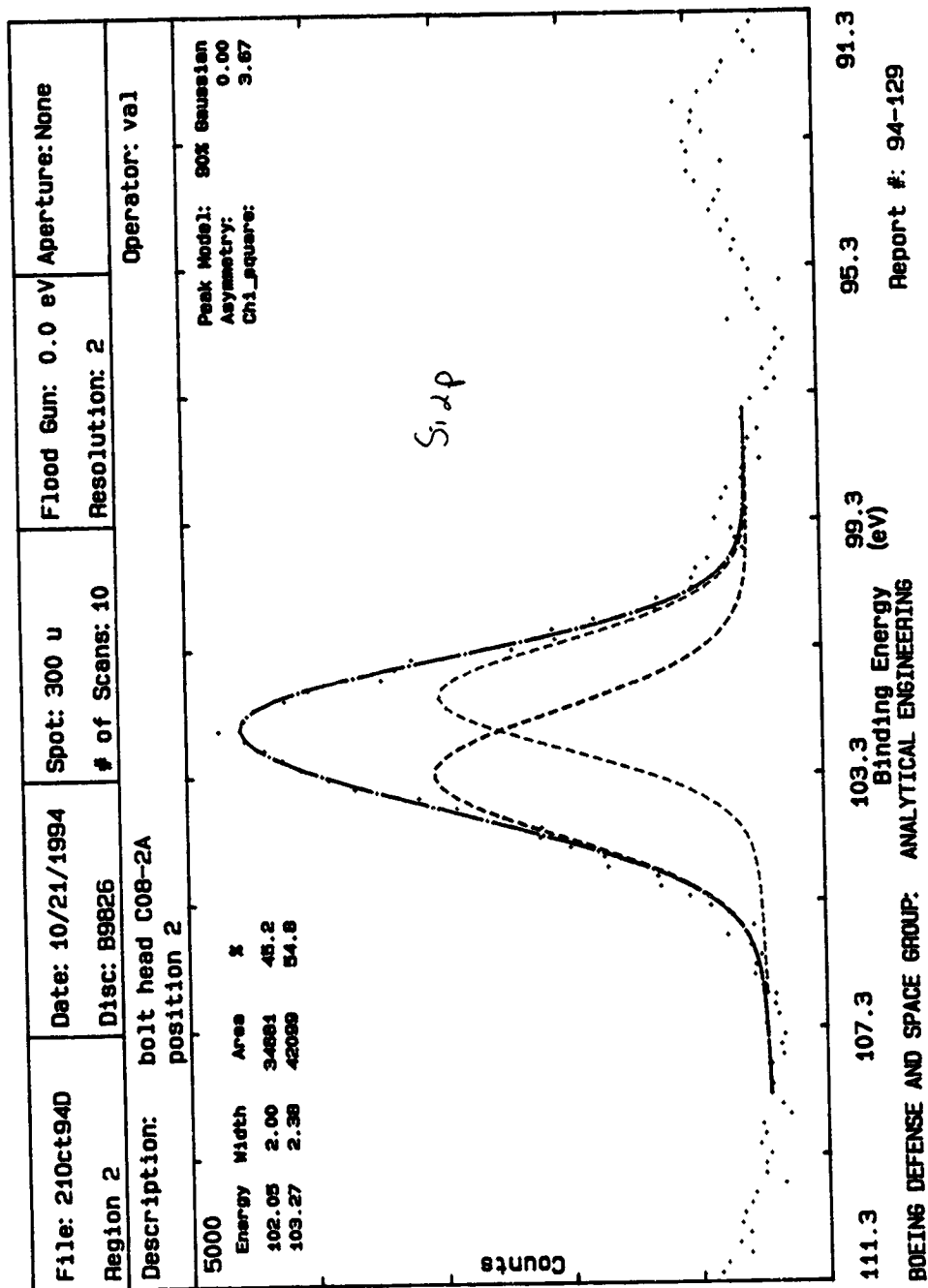


Figure G-16. Carbon 1s spectrum for bolt C8-2a, position 2.



$\Delta_{hc} = -0.7$

Figure G-17. Silicon 2p spectrum for bolt C8-2a, position 2.

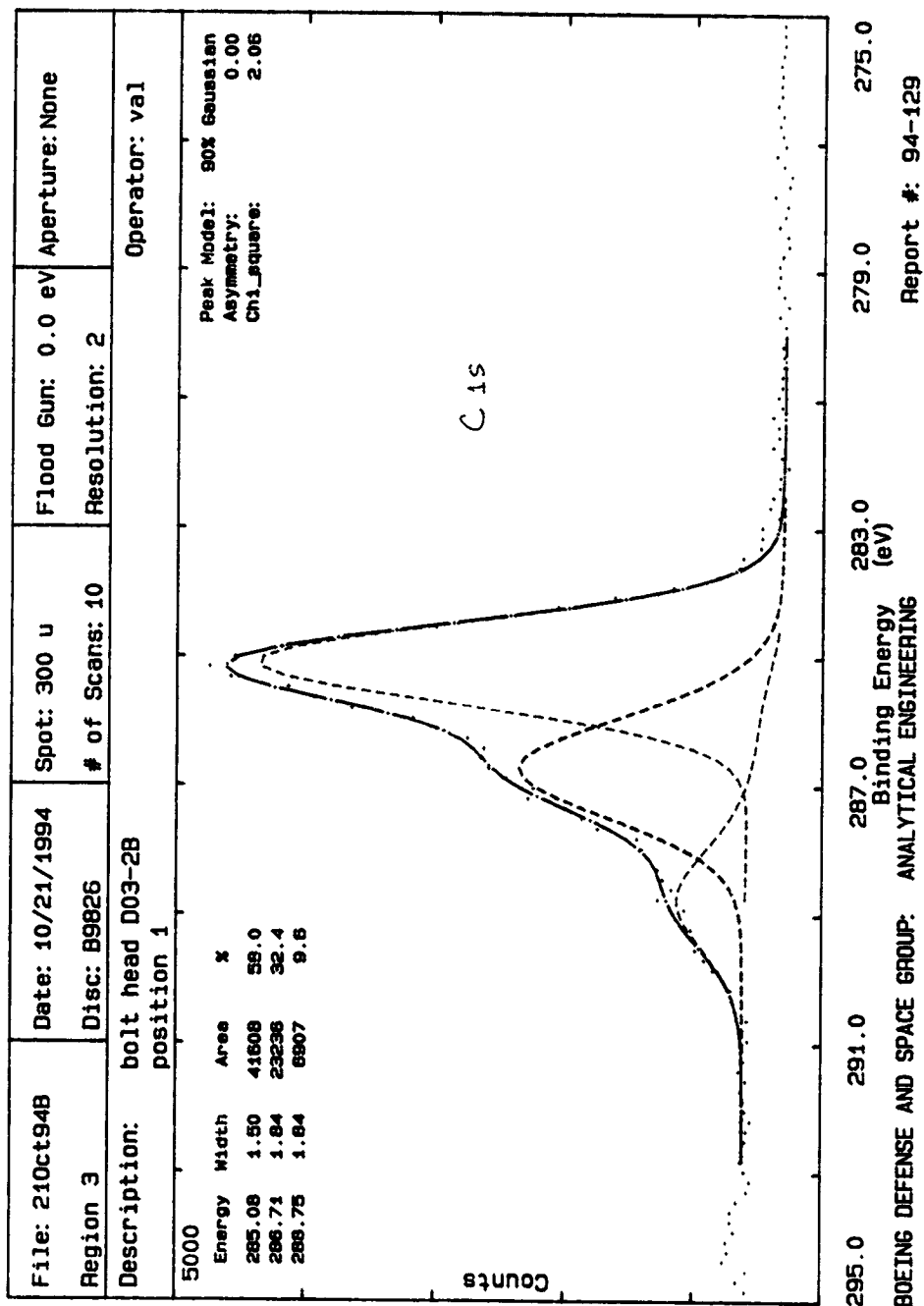
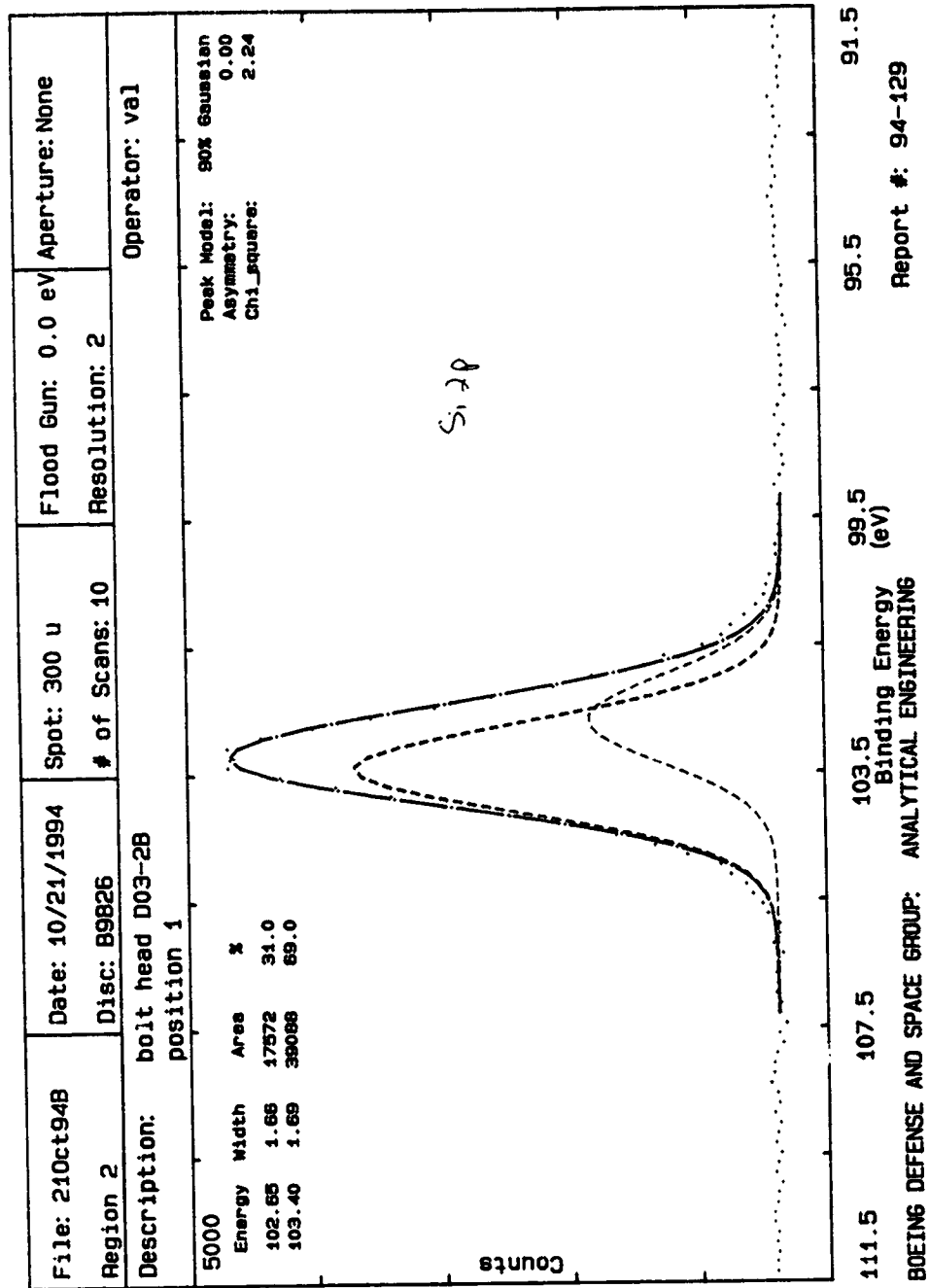


Figure G-18. Carbon 1s spectrum for bolt D3-2b, position 1.



Abe = 0.5

Figure G-19. Silicon 2p spectrum for bolt D3-2b, position 1.

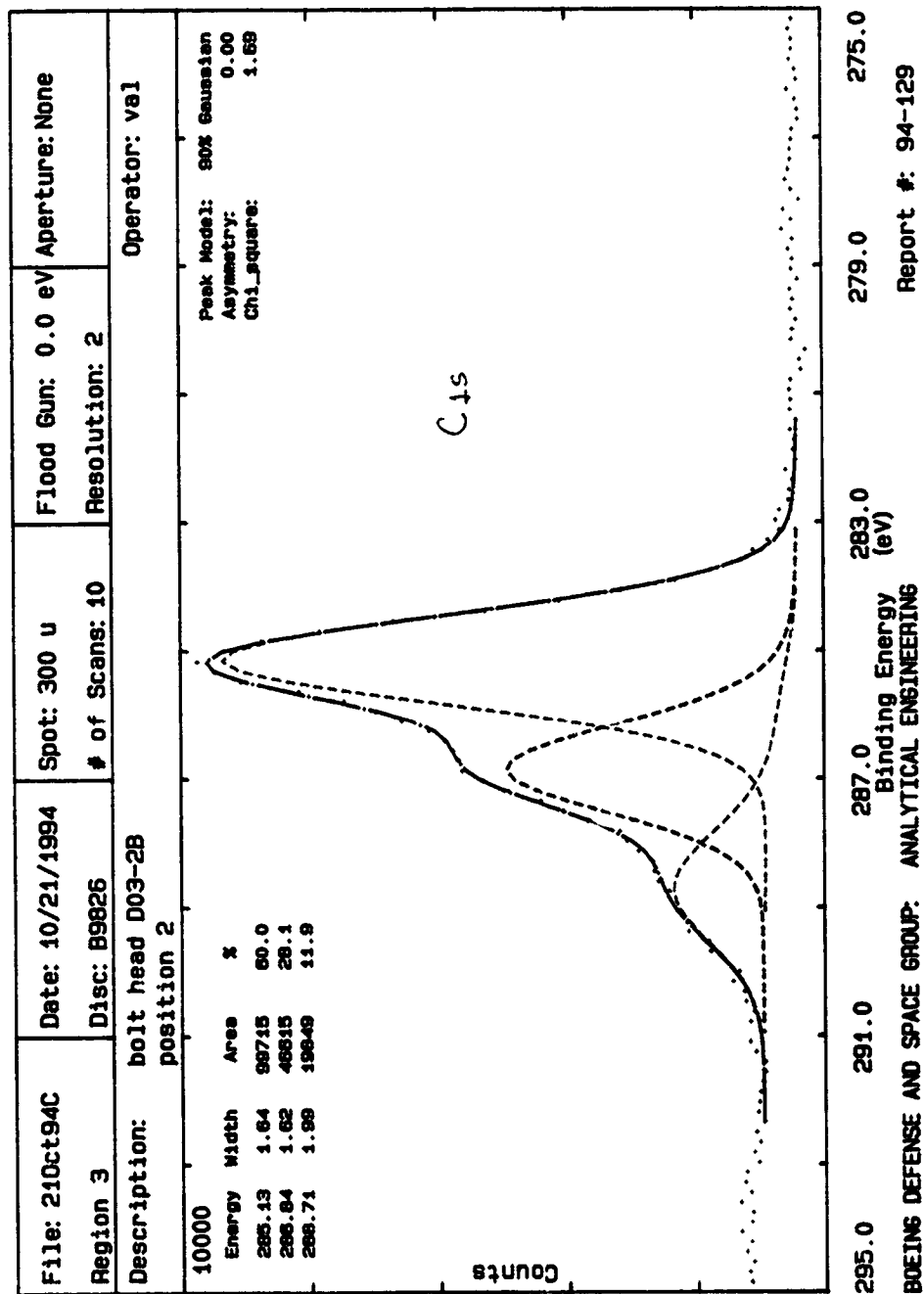
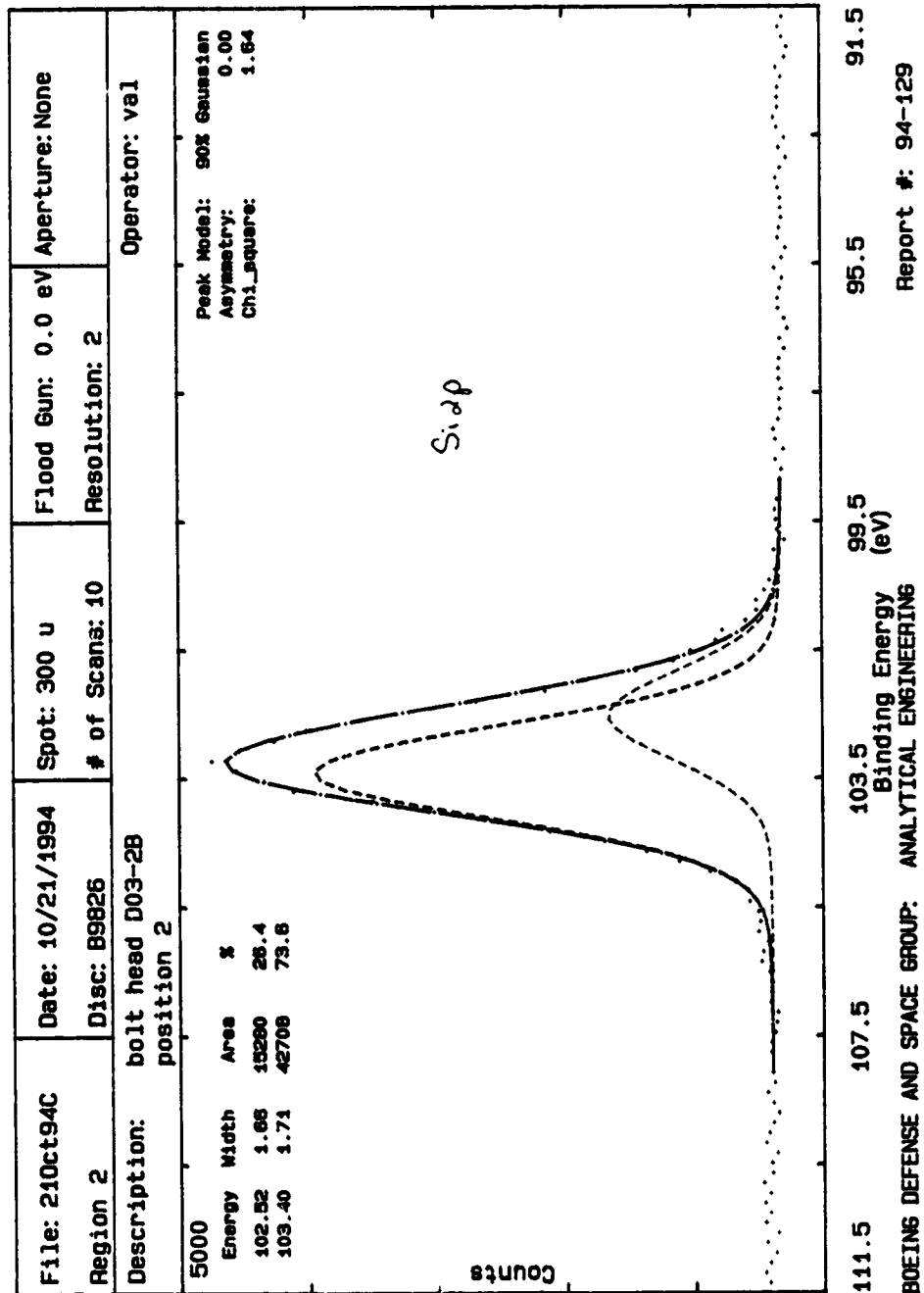


Figure G-20. Carbon 1s spectrum for bolt D3-2b, position 2.



Abc = 0.5 eV

Figure G-21. Silicon 2p spectrum for bolt D3-2b, position 2.

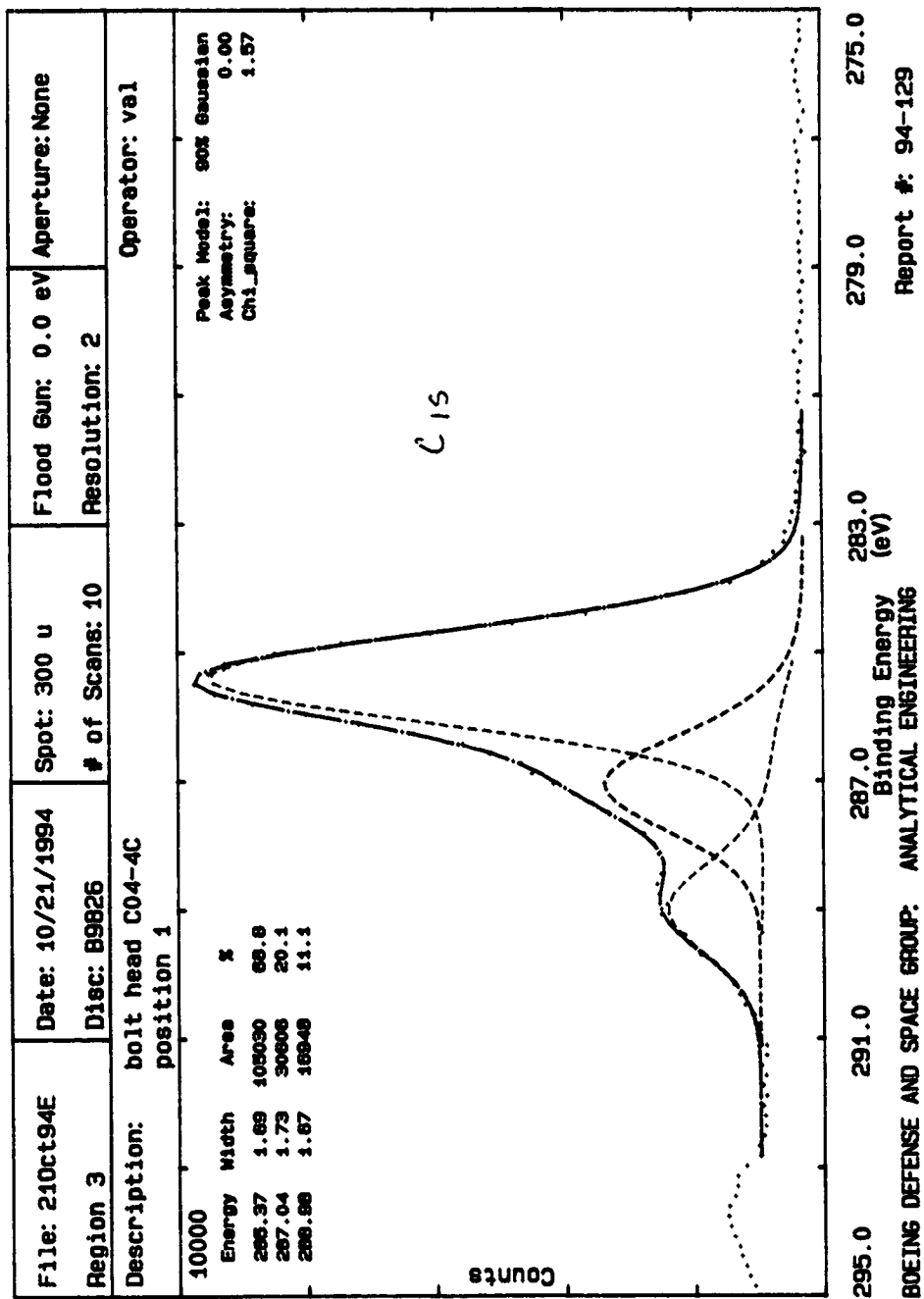


Figure G-22. Carbon 1s spectrum for bolt C4-4c, position 1.

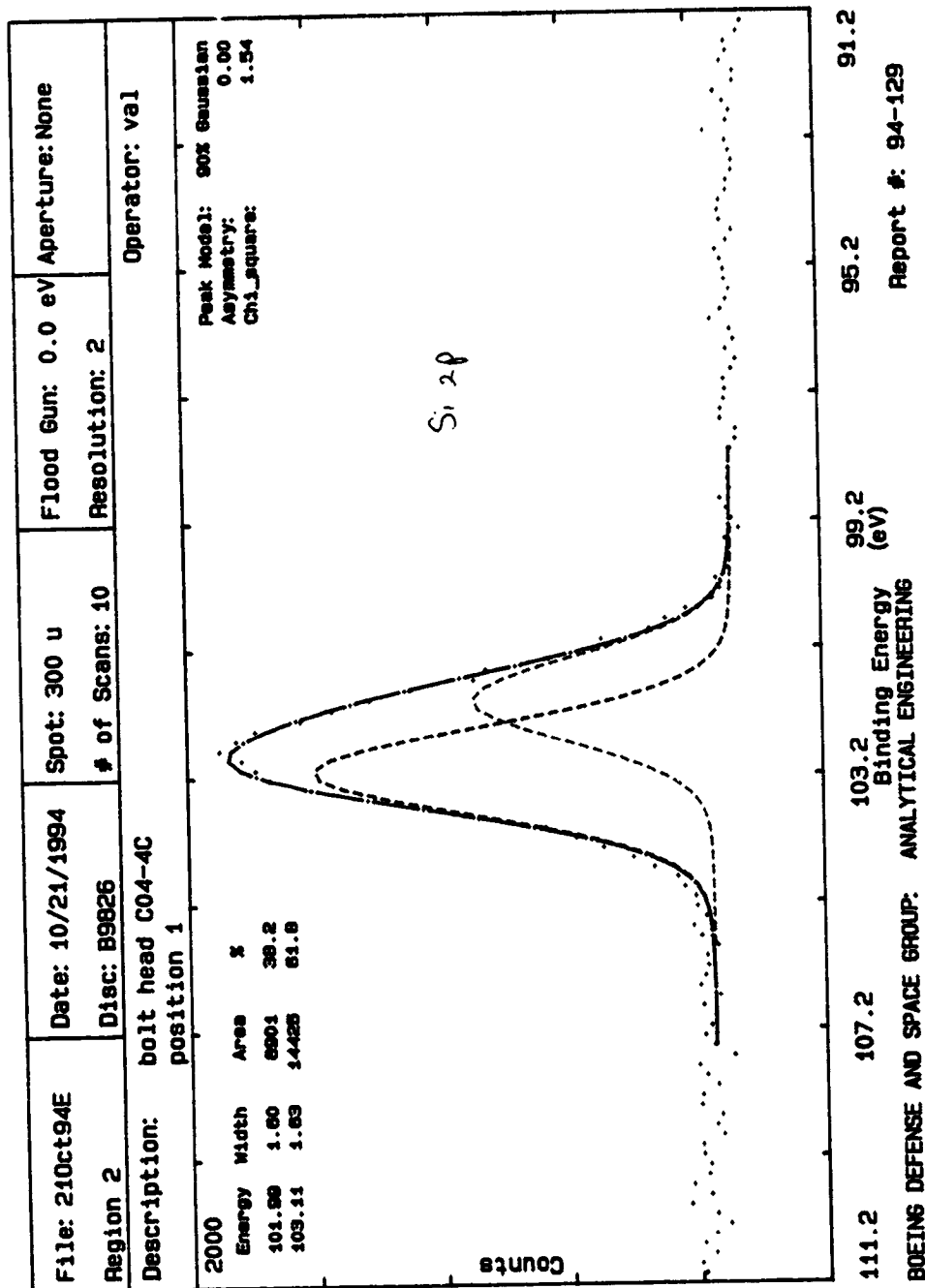


Figure G-23. Silicon 2p spectrum for bolt C4-4c, position 1.

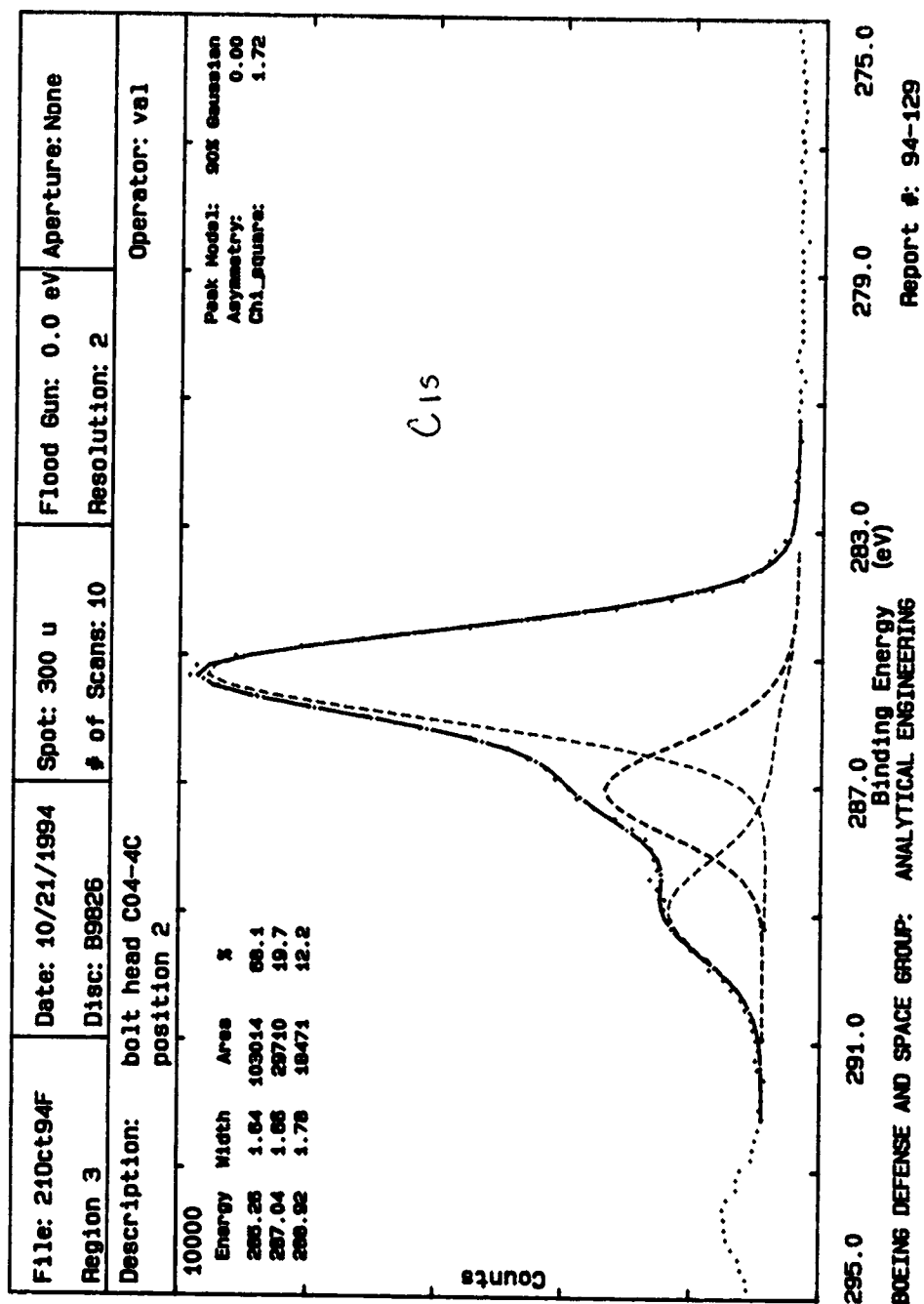
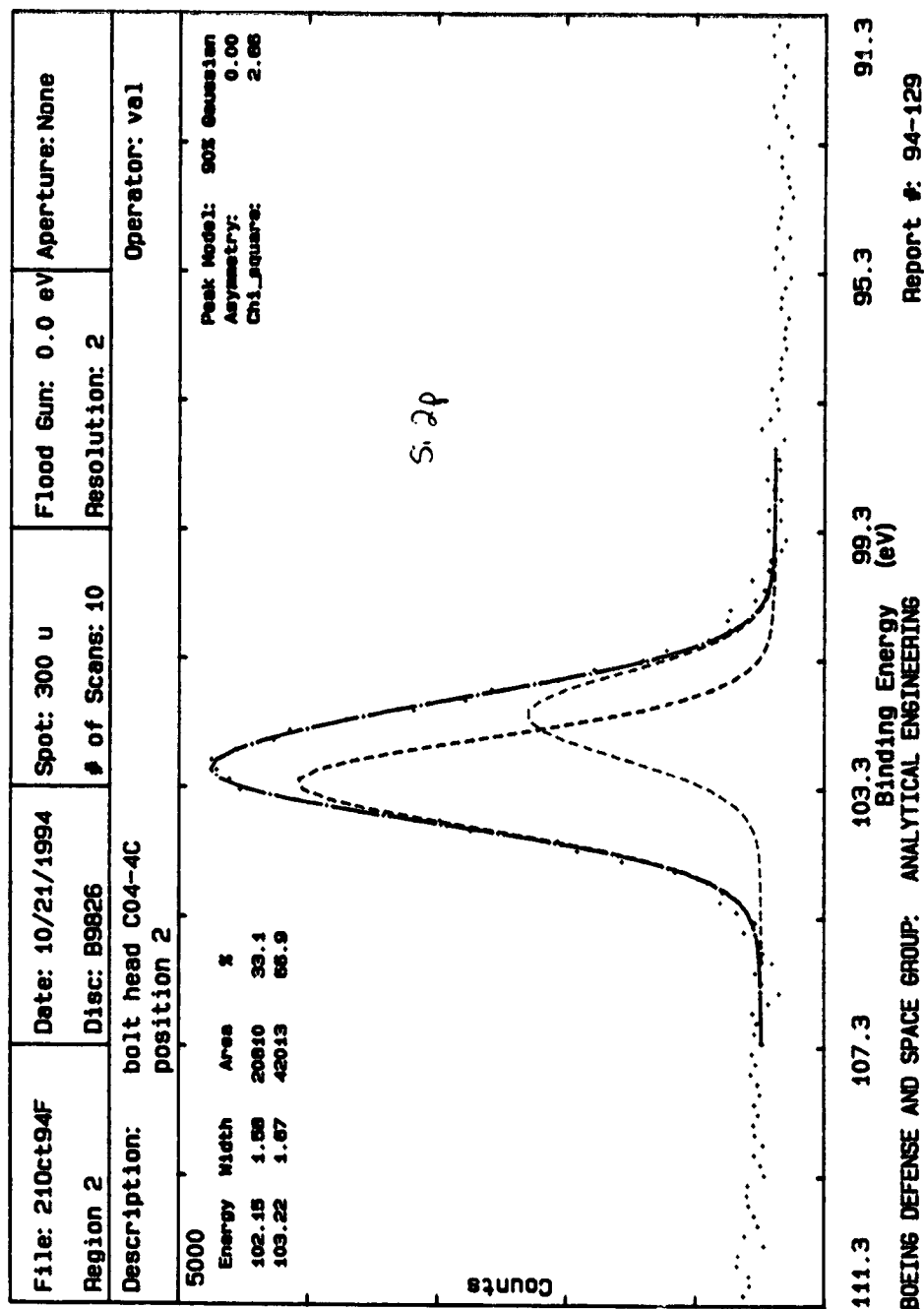


Figure G-24. Carbon 1s spectrum for bolt C4-4c, position 2.



$\sqrt{be} = 0.7$

Figure G-25. Silicon 2p spectrum for bolt C4-4c, position 2.

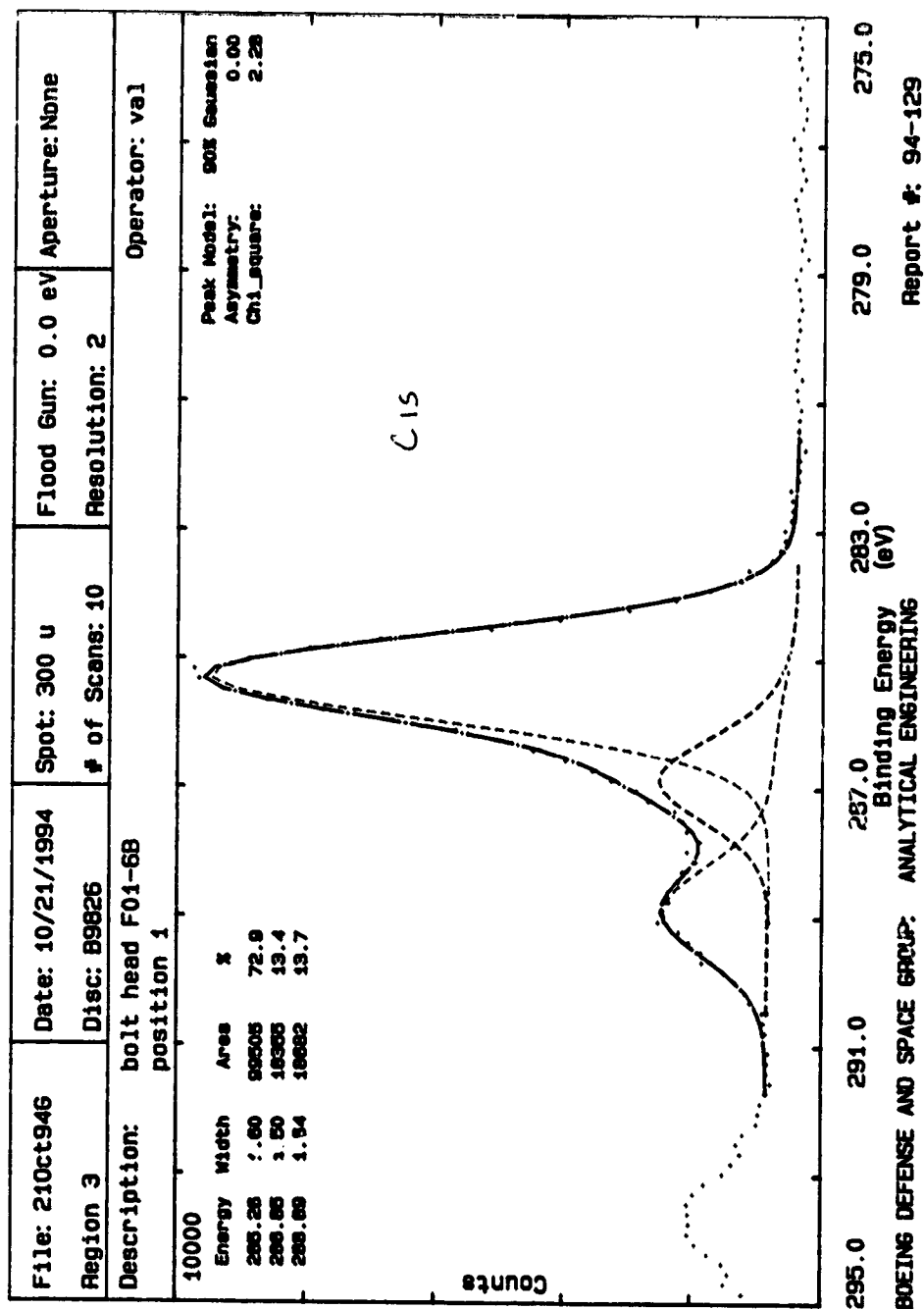
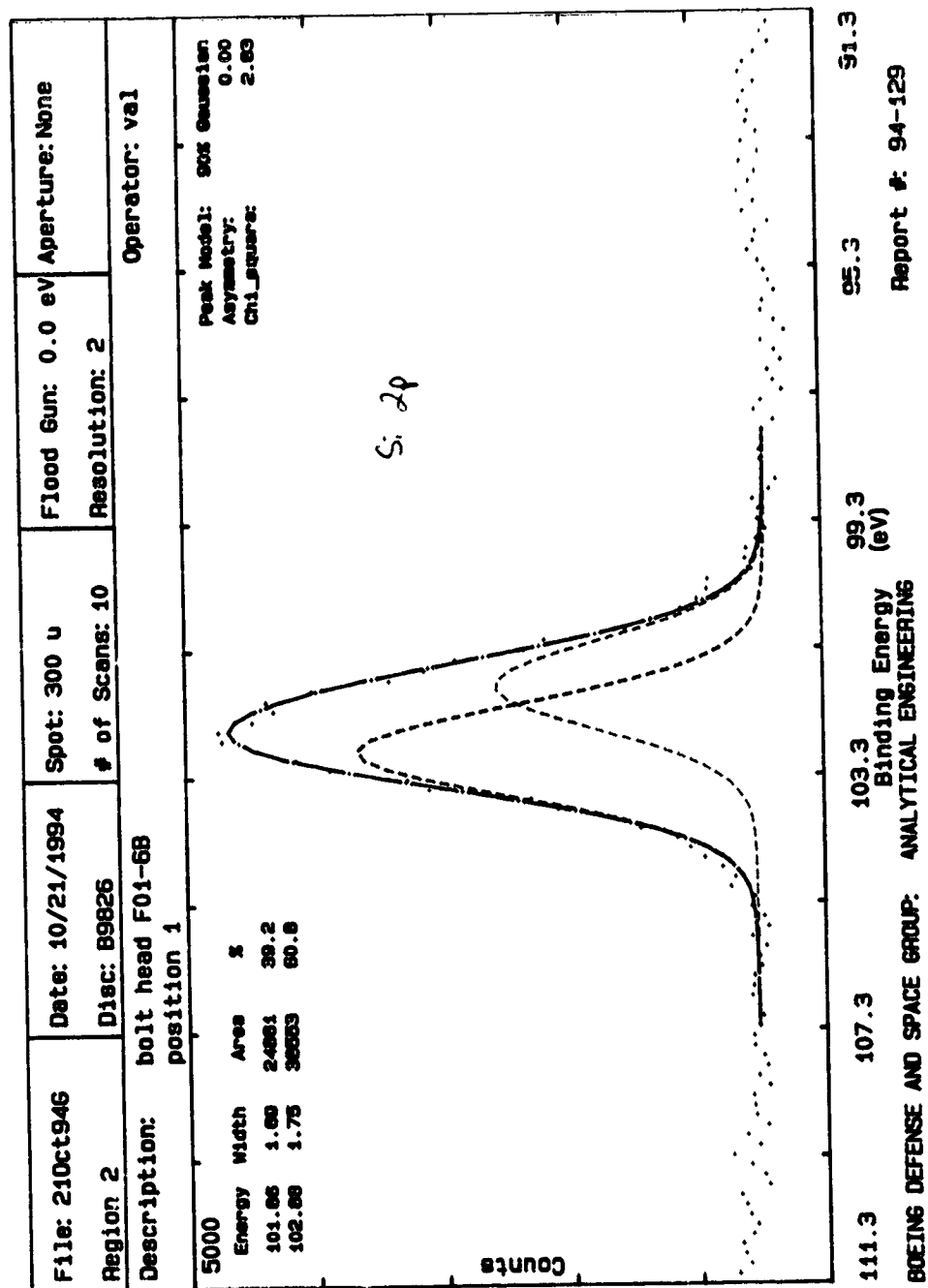


Figure G-26. Carbon 1s spectrum for bolt F1-6b, position 1.



Δbe = 0.7

Figure G-27. Silicon 2p spectrum for bolt F1-6b, position 1.

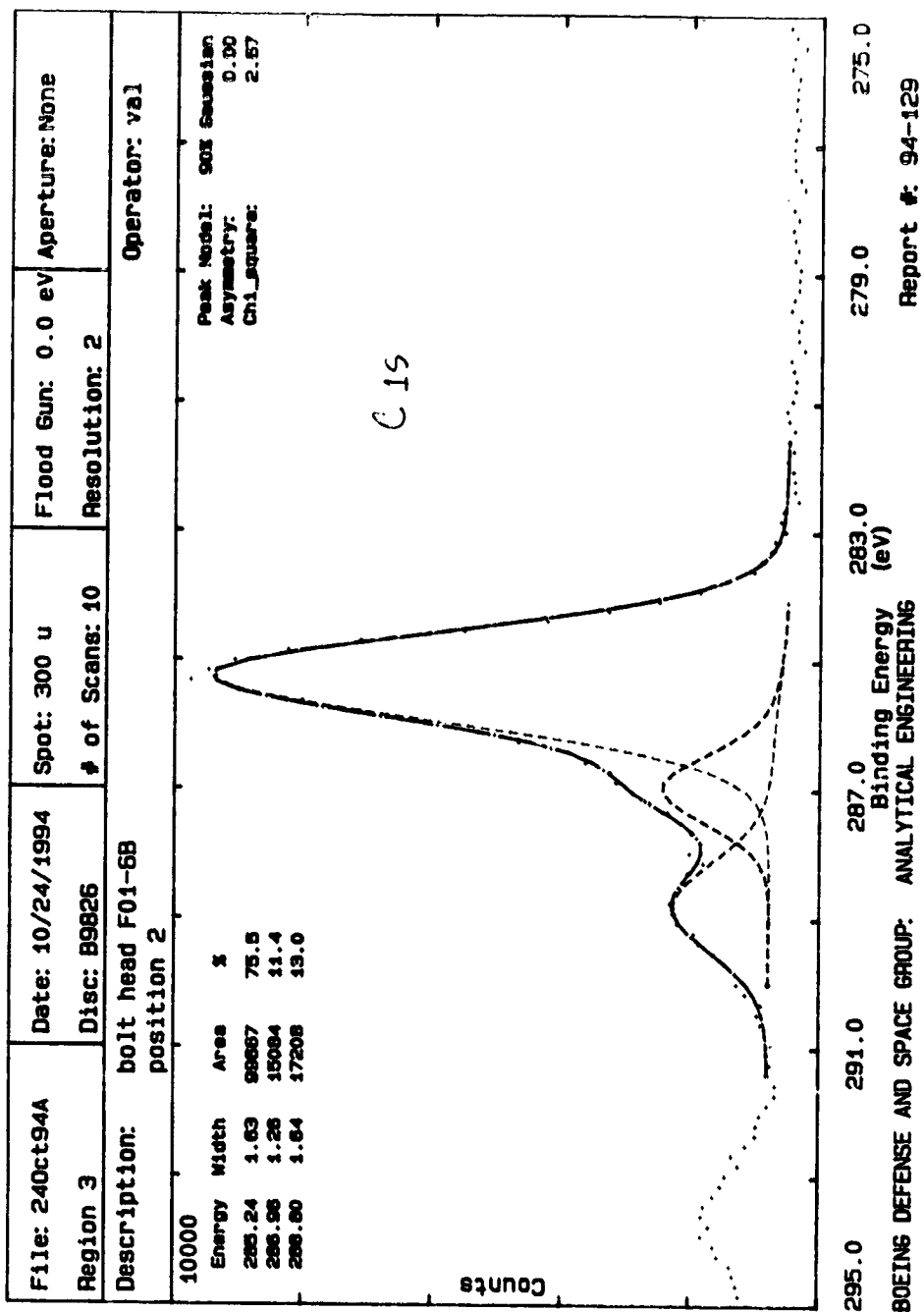
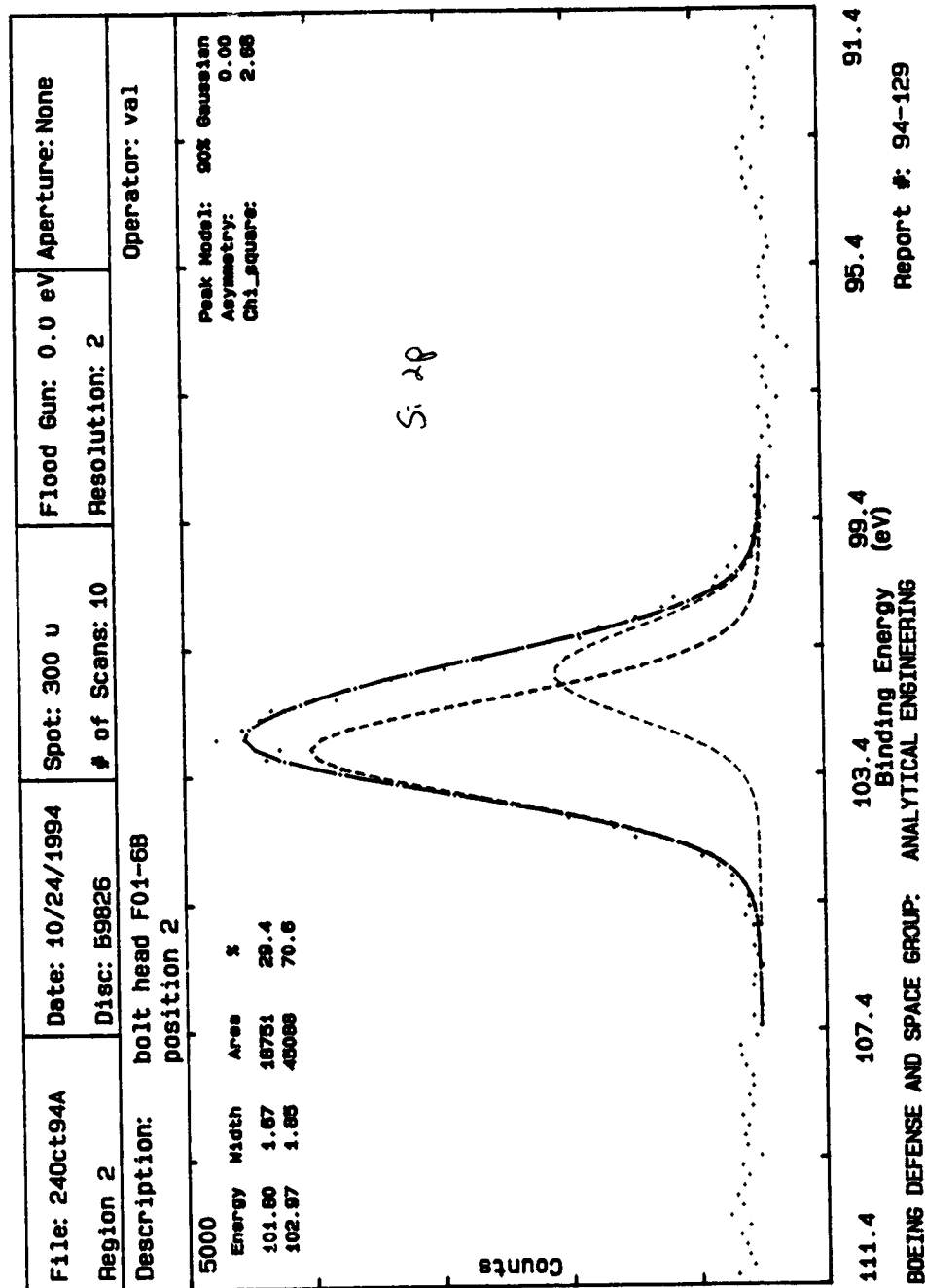


Figure G-28. Carbon 1s spectrum for bolt F1-6b, position 2.



Shc = 86 eV

Figure G-29. Silicon 2p spectrum for bolt F1-6b, position 2.

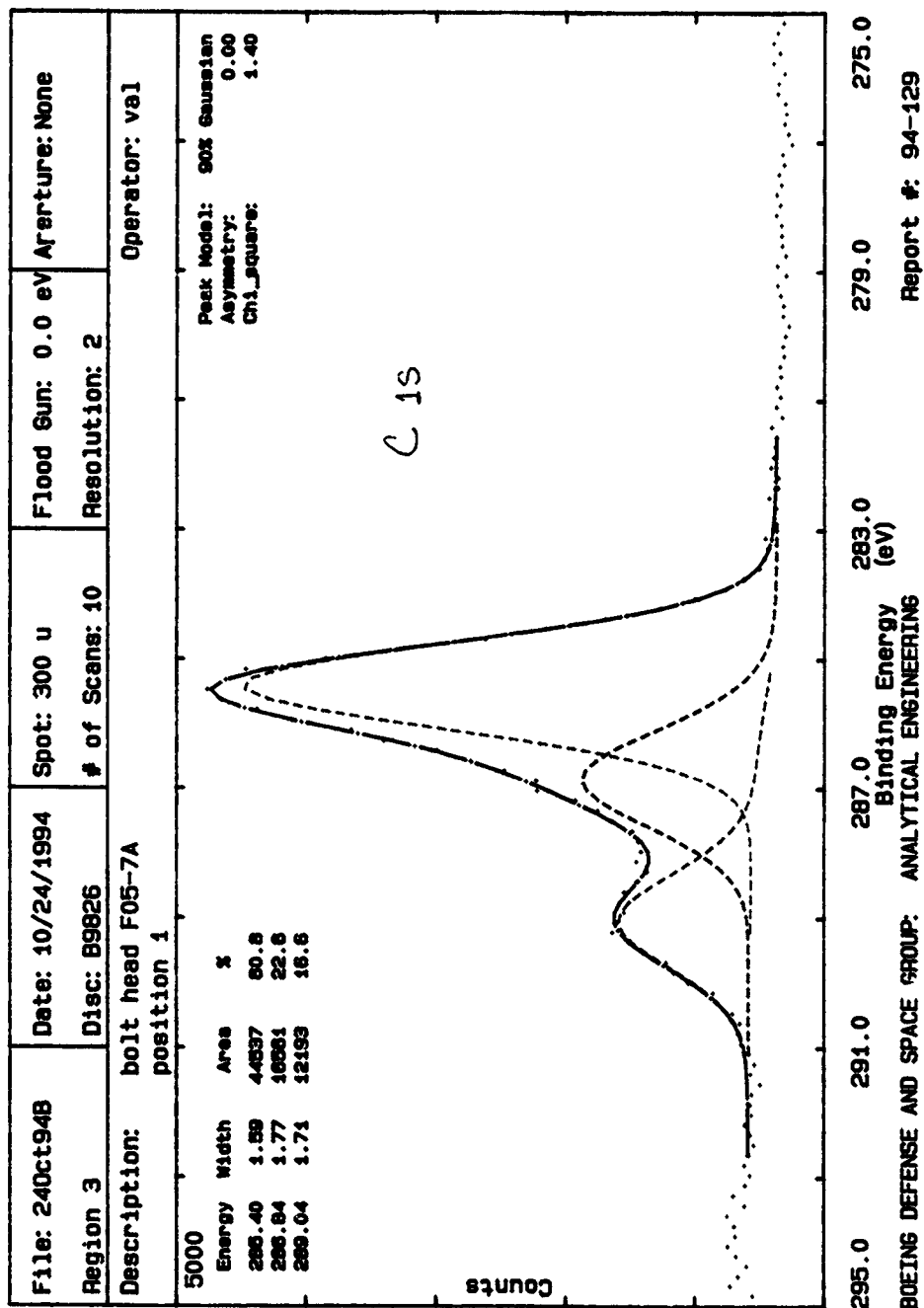


Figure G-30. Carbon 1s spectrum for bolt F5-7a, position 1.

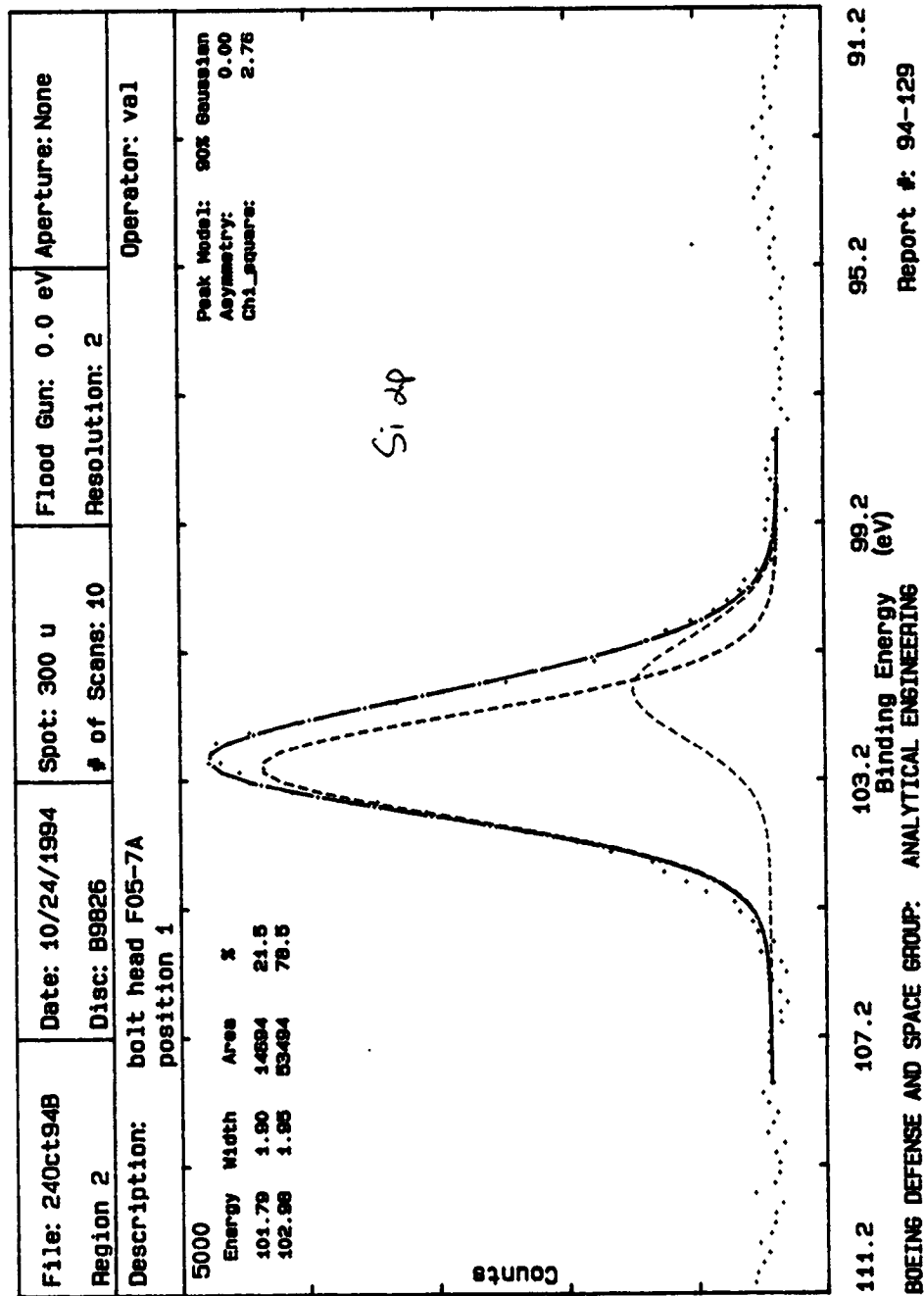


Figure G-31. Silicon 2p spectrum for bolt F5-7a, position 1.

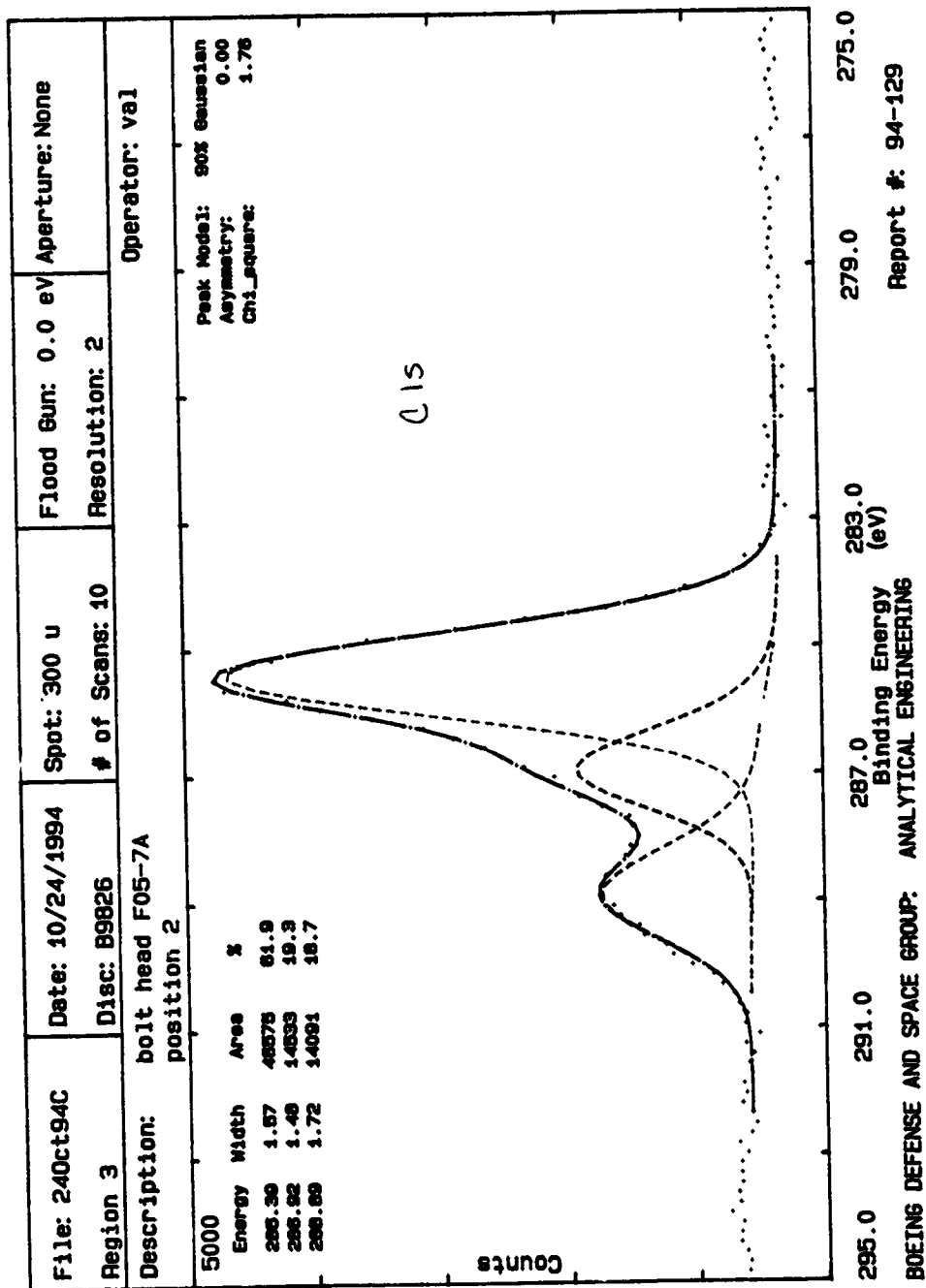
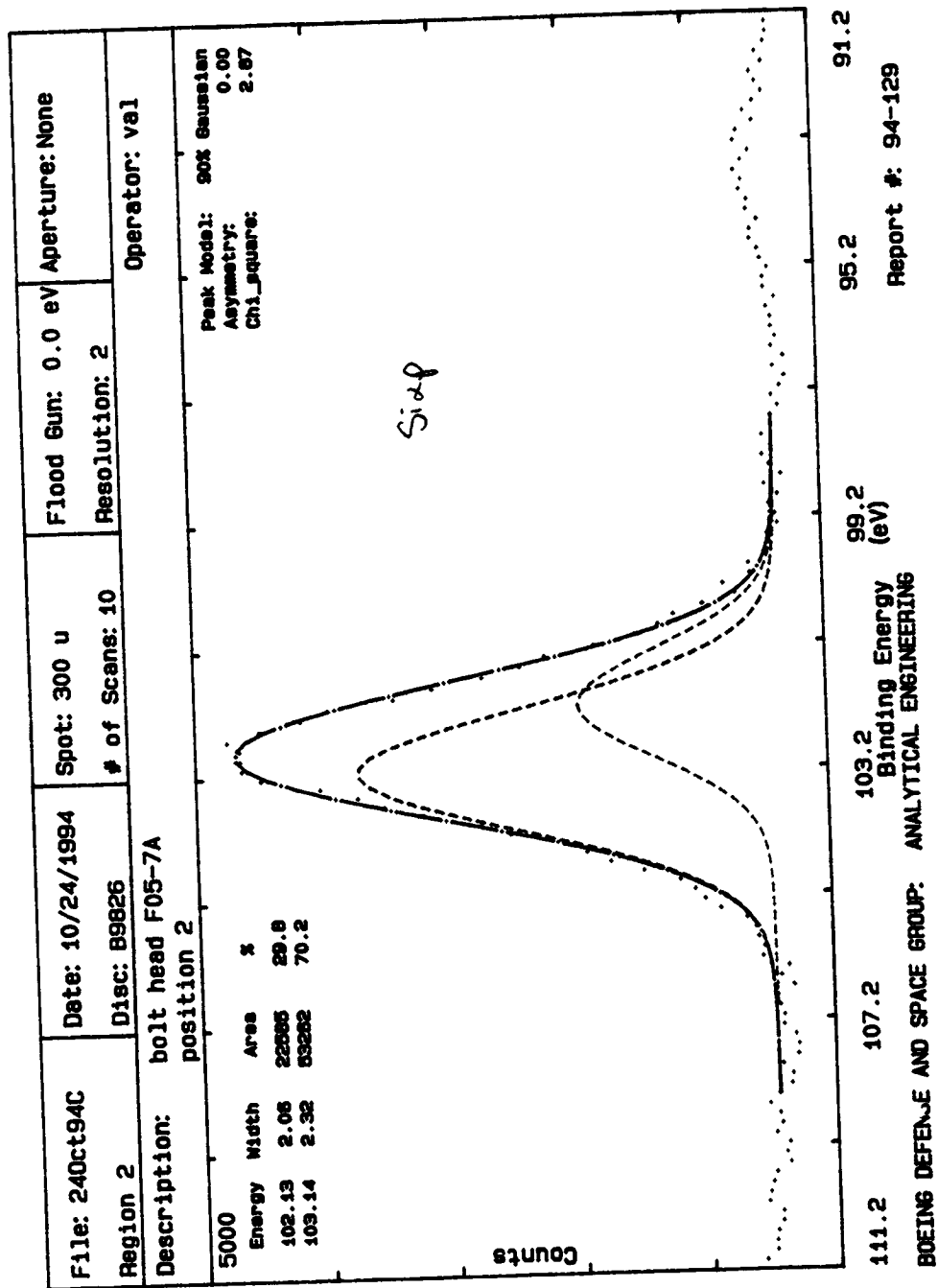


Figure G-32. Carbon 1s spectrum for bolt F5-7a, position 2.



$\Delta be = -0.8 \text{ eV}$

Figure G-33. Silicon 2p spectrum for bolt F5-7a, position 2.

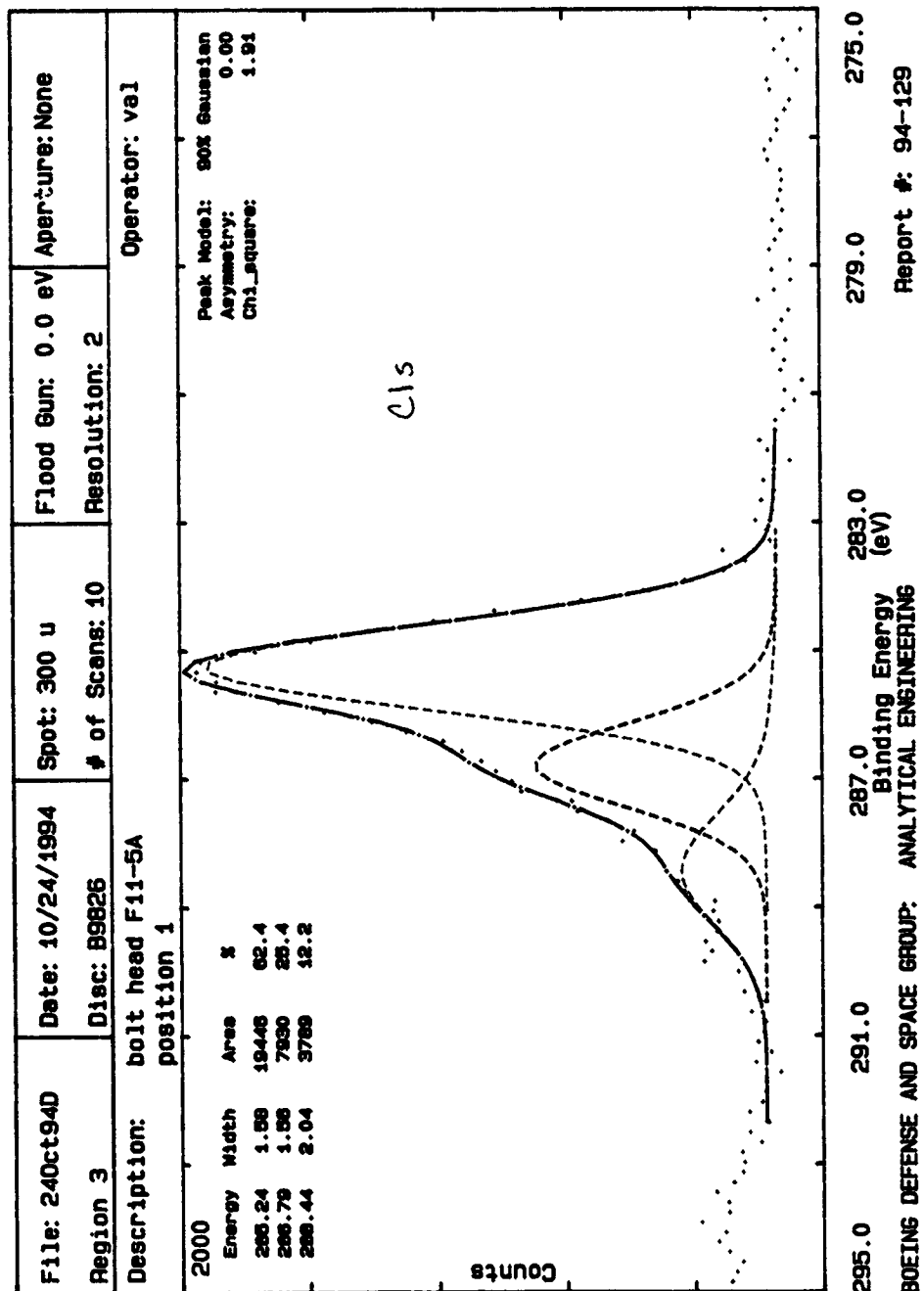
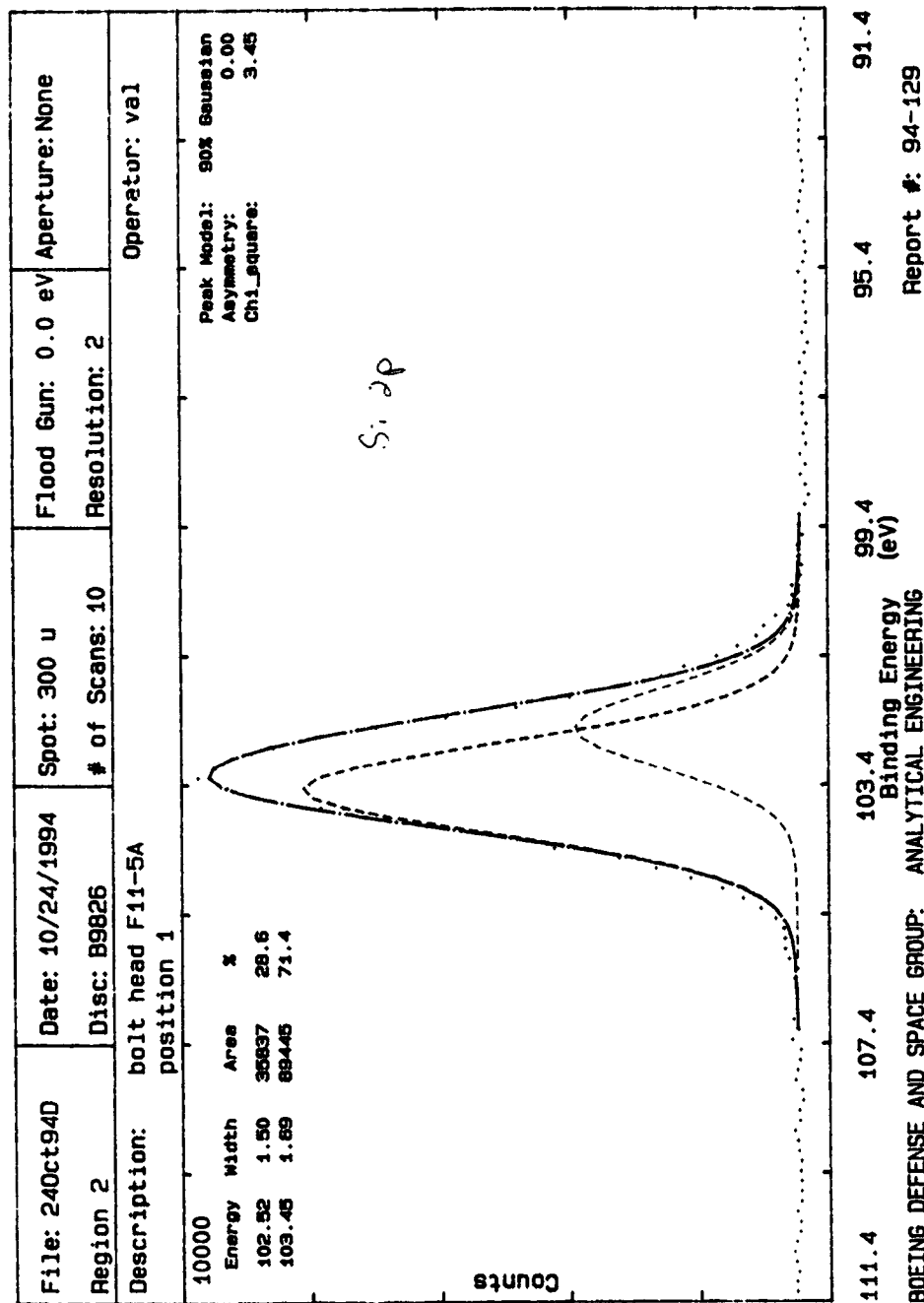


Figure G-34. Carbon 1s spectrum for bolt F11-5a, position 1.



$\text{Vbe} = -0.6\text{eV}$

Figure G-35. Silicon 2p spectrum for bolt F11-5a, position 1.

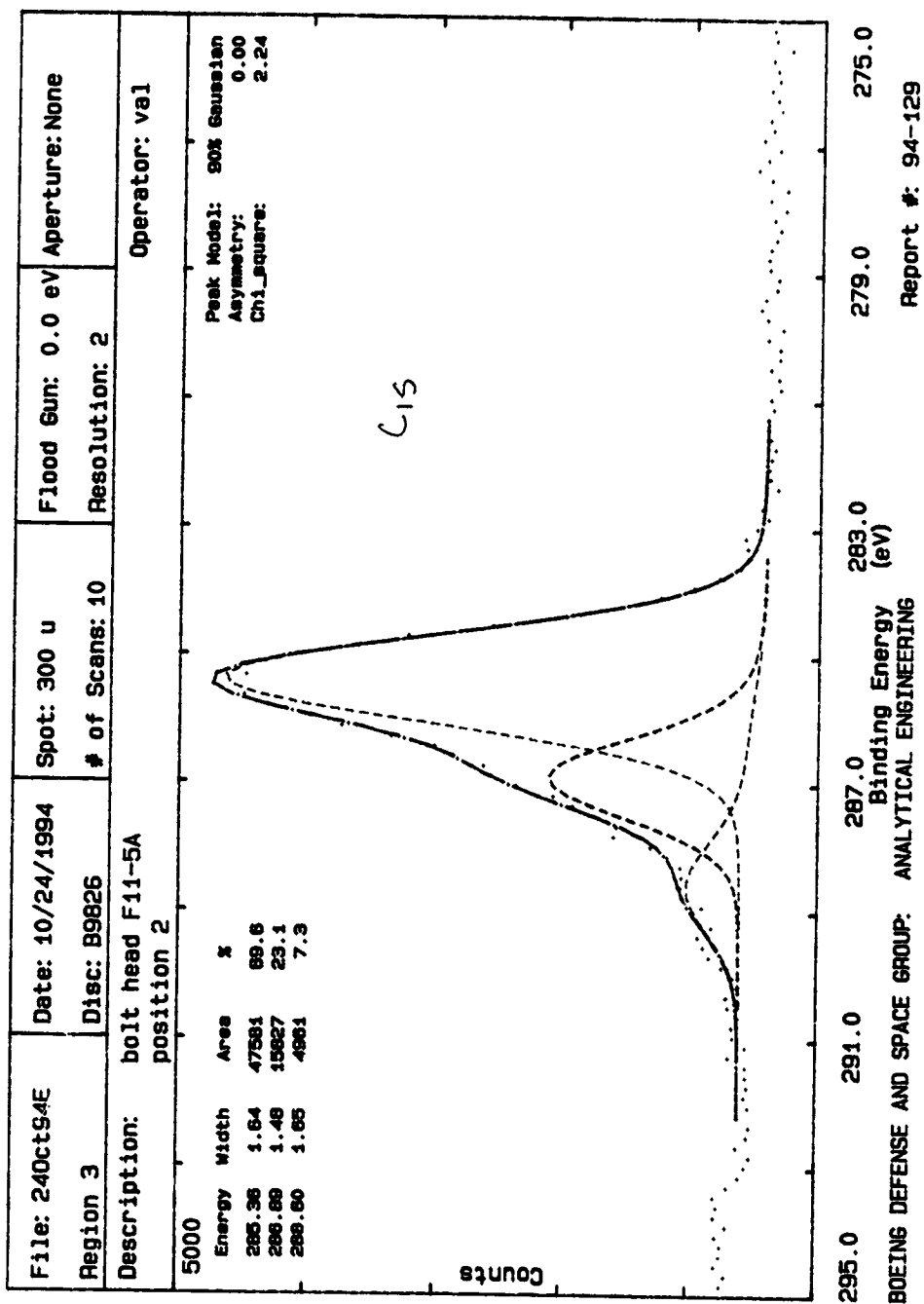


Figure G-36. Carbon 1s spectrum for bolt F11-5a, position 2.

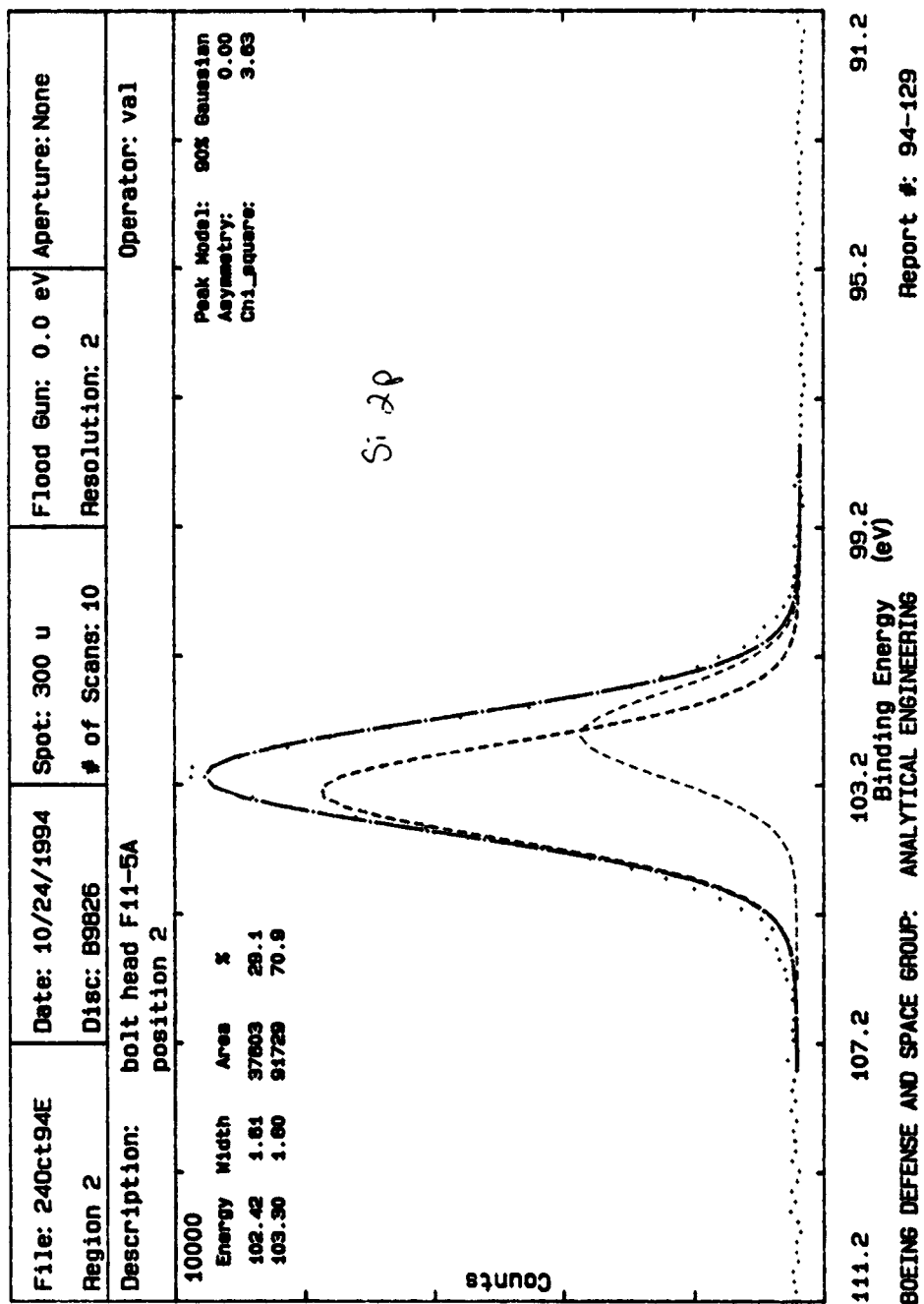


Figure G-37. Silicon 2p spectrum for bolt F11-5a, position 2.

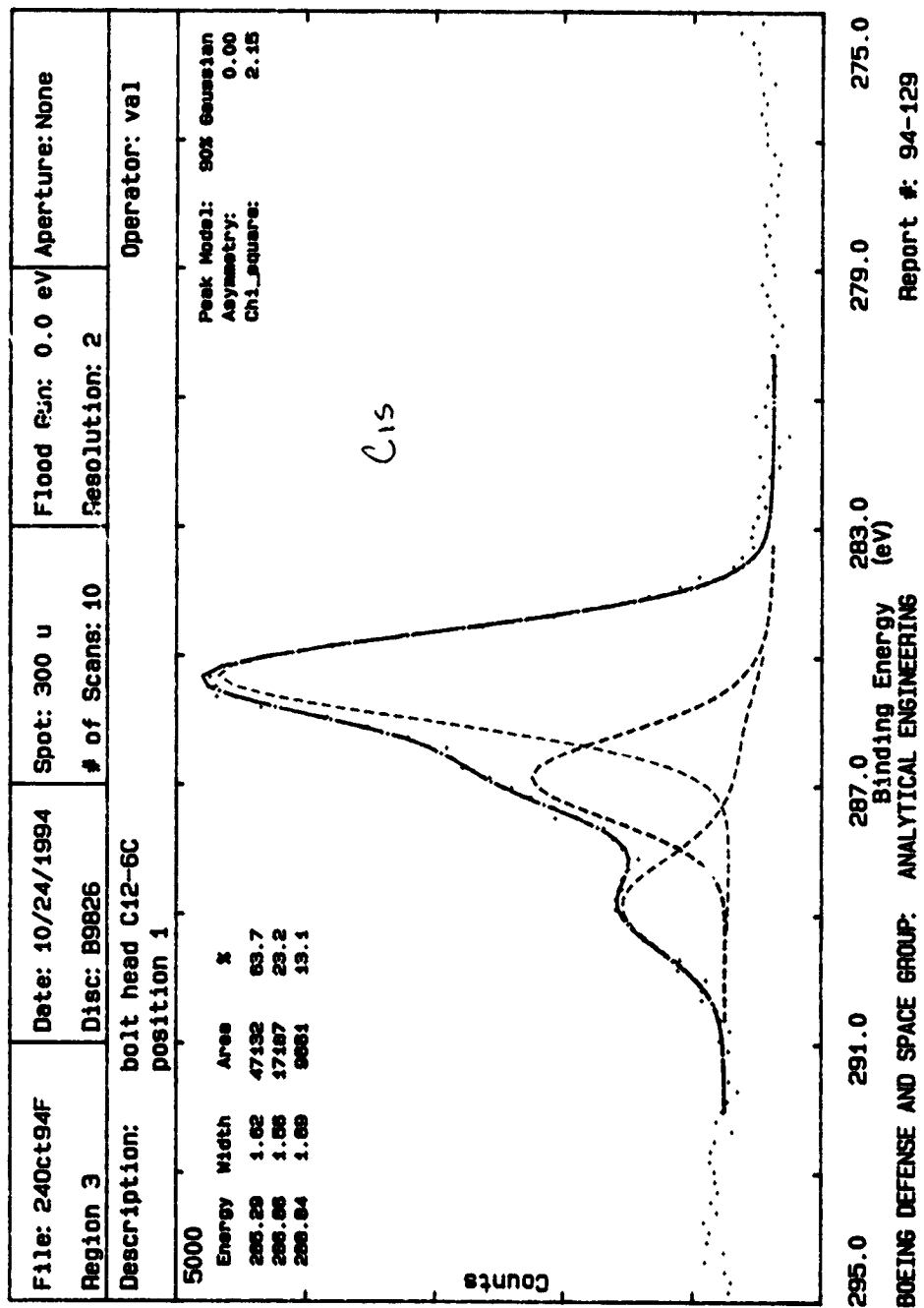


Figure G-38. Carbon 1s spectrum for bolt C12-6c, position 1.

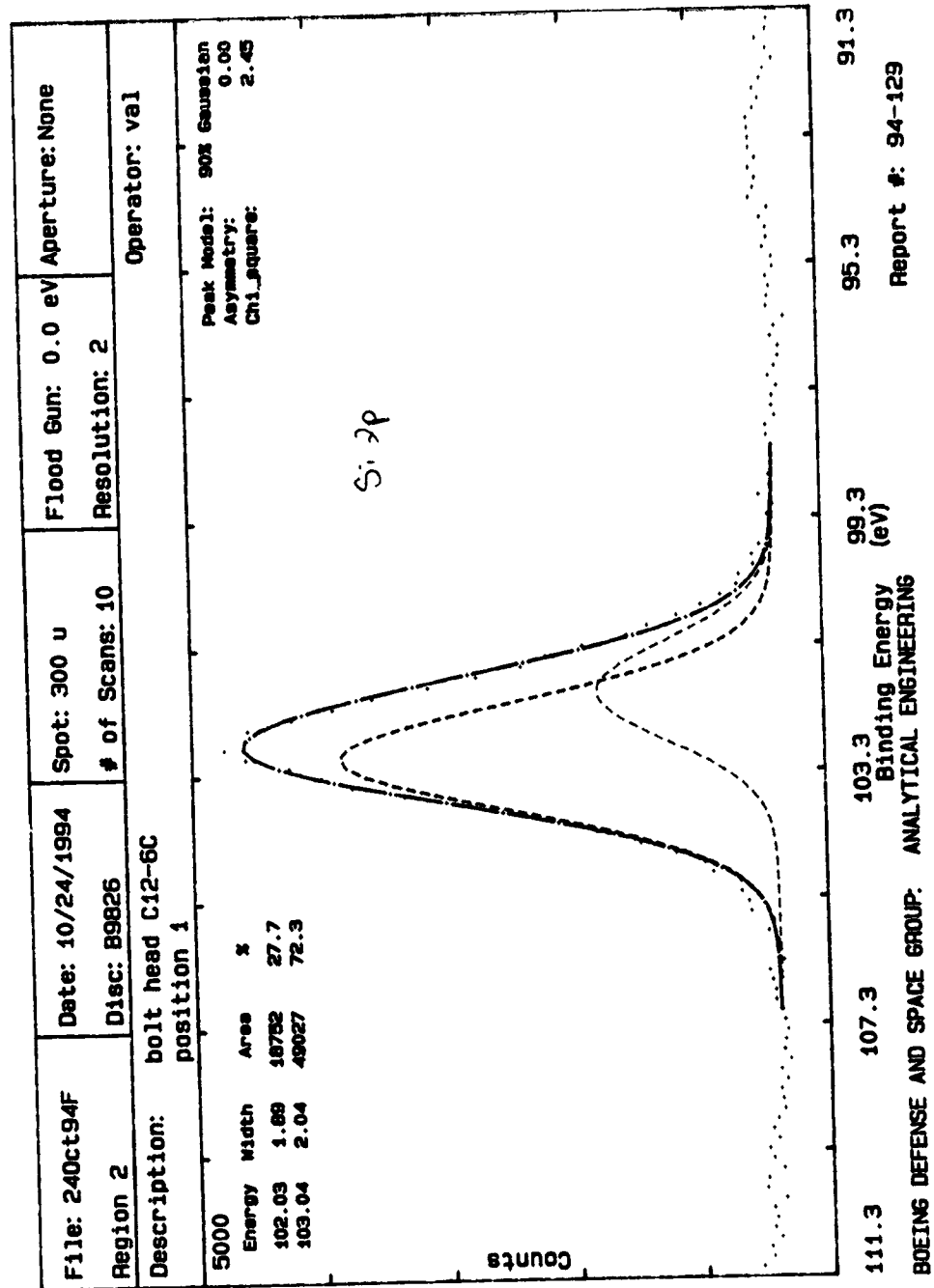


Figure G-39. Silicon 2p spectrum for bolt C12-6c, position 1.

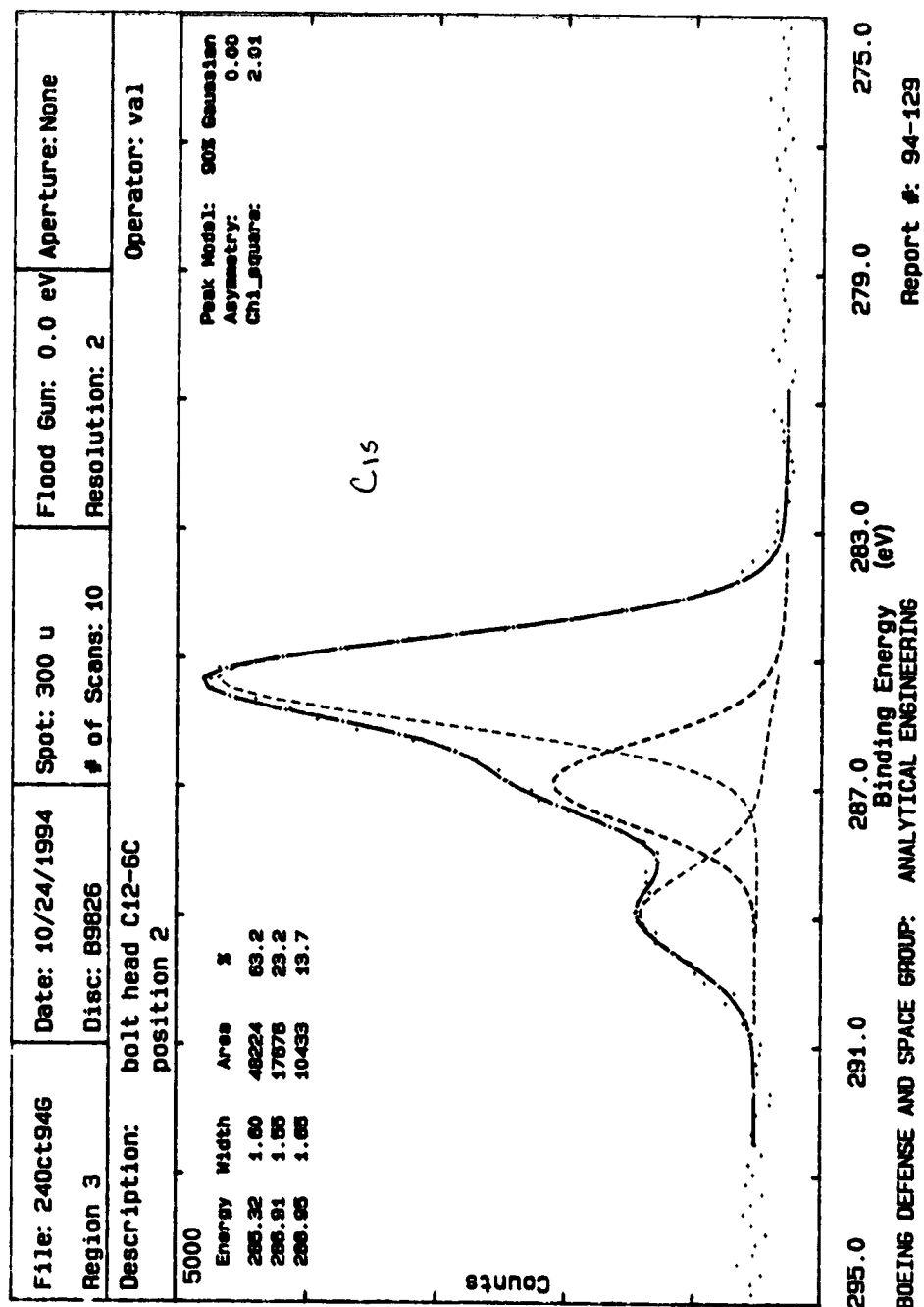


Figure G-40. Carbon 1s spectrum for bolt C12-6c, position 2.

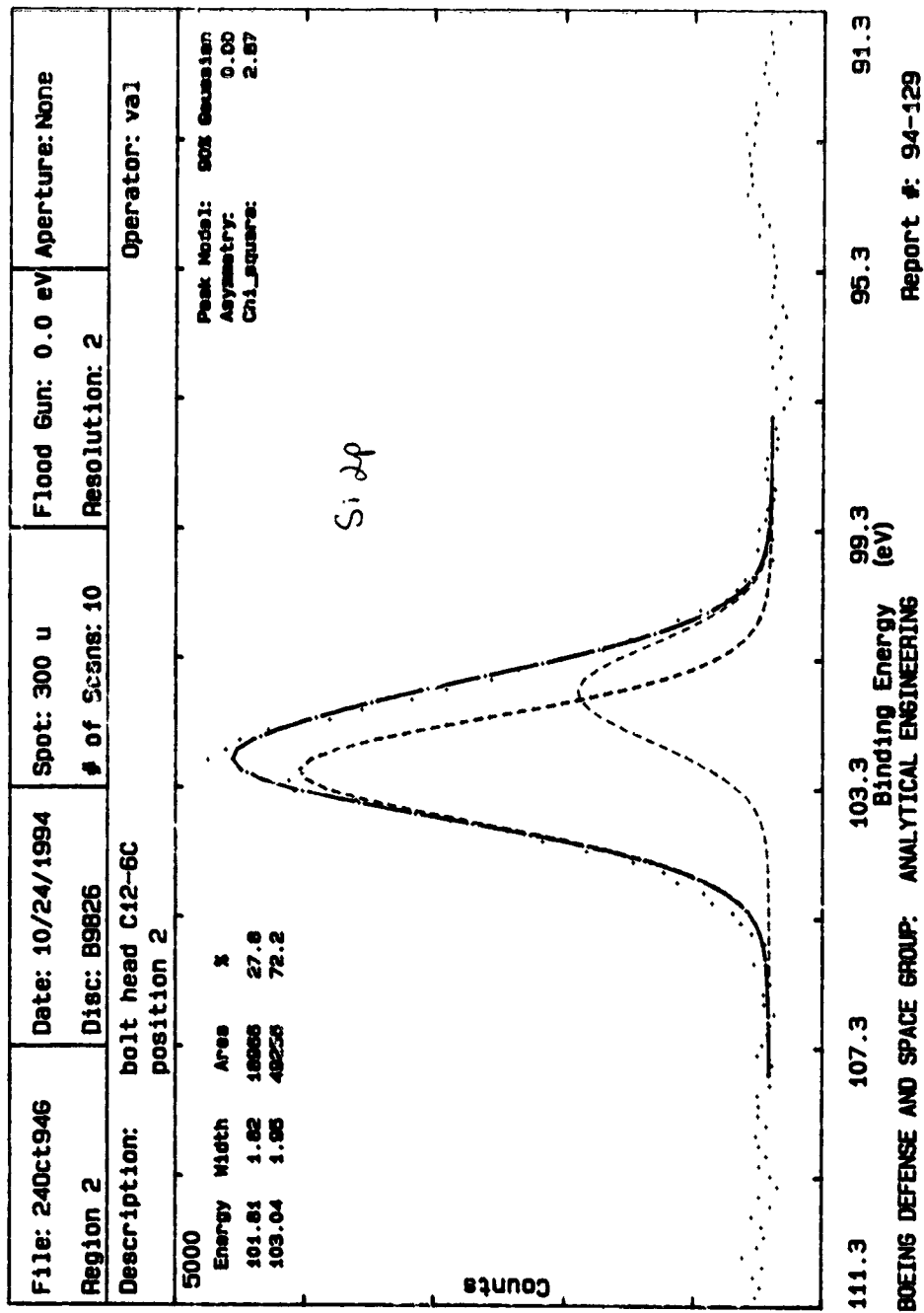
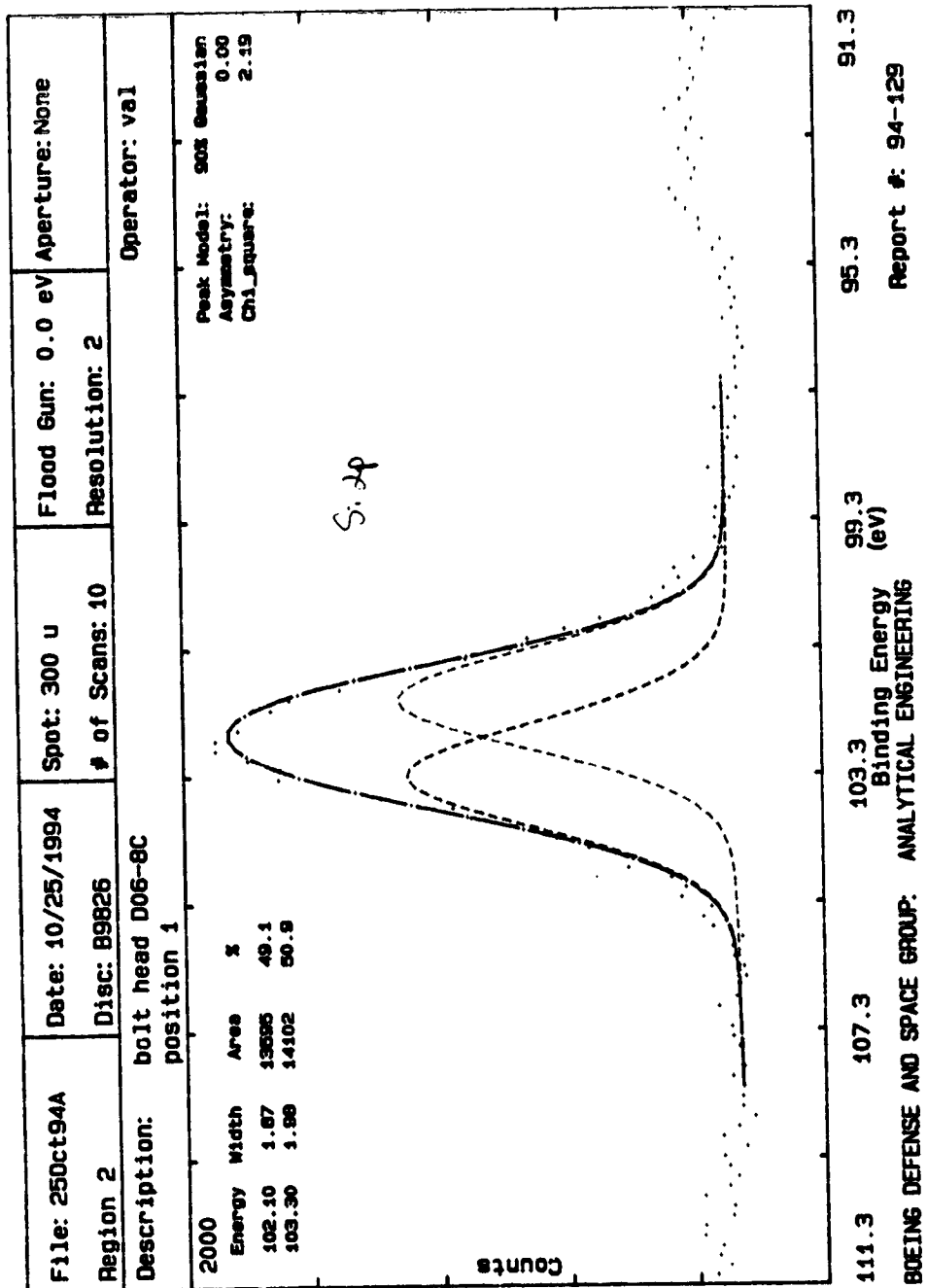


Figure G-41. Silicon 2p spectrum for bolt C12-6c, position 2.



$\Delta be = -0.7 eV$

Figure G-42. Carbon 1s spectrum for bolt D6-8c, position 1.

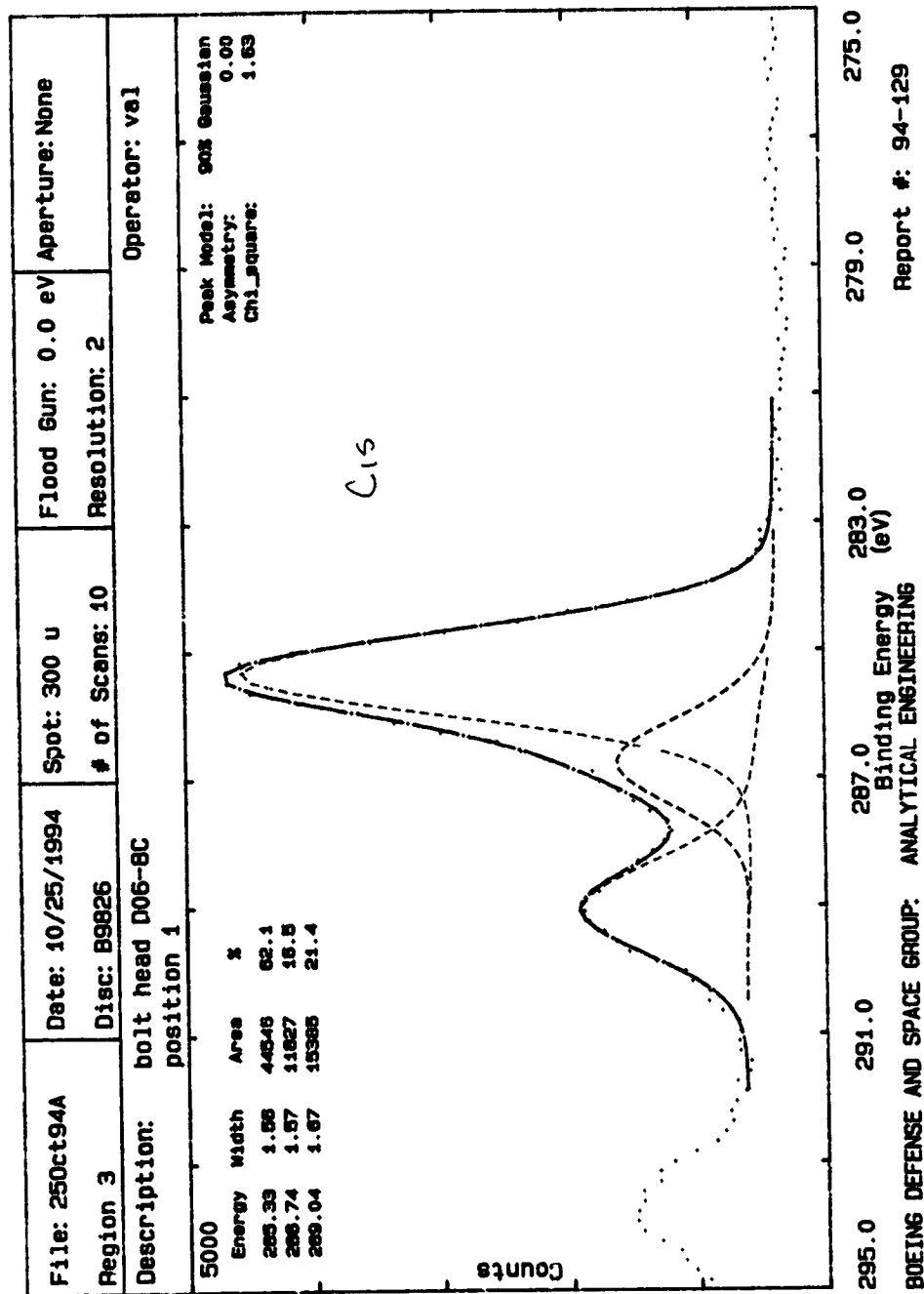


Figure G-43. Silicon 2p spectrum for bolt D6-8c, position 1.

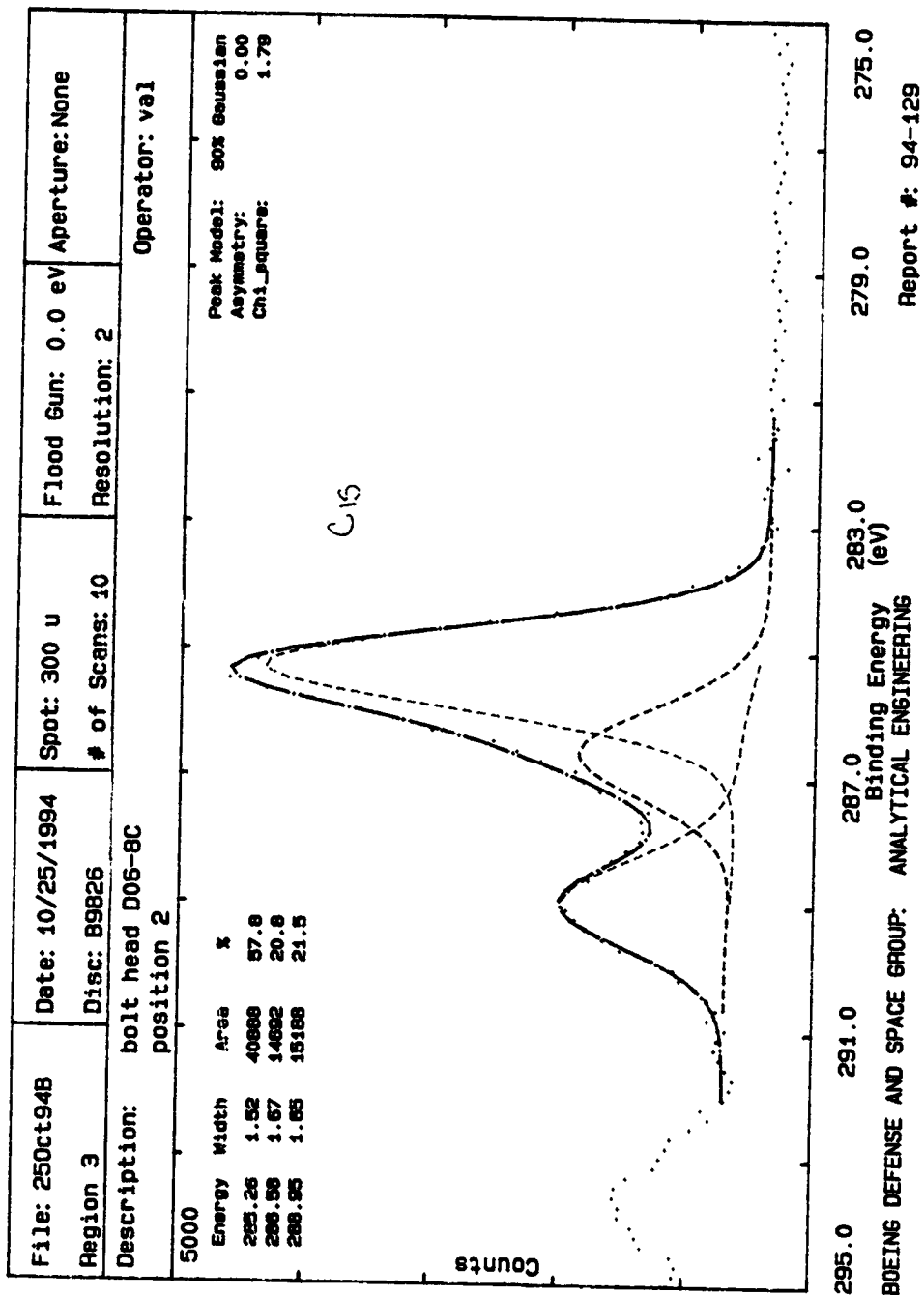


Figure G-44. Carbon 1s spectrum for bolt D6-8c, position 2.

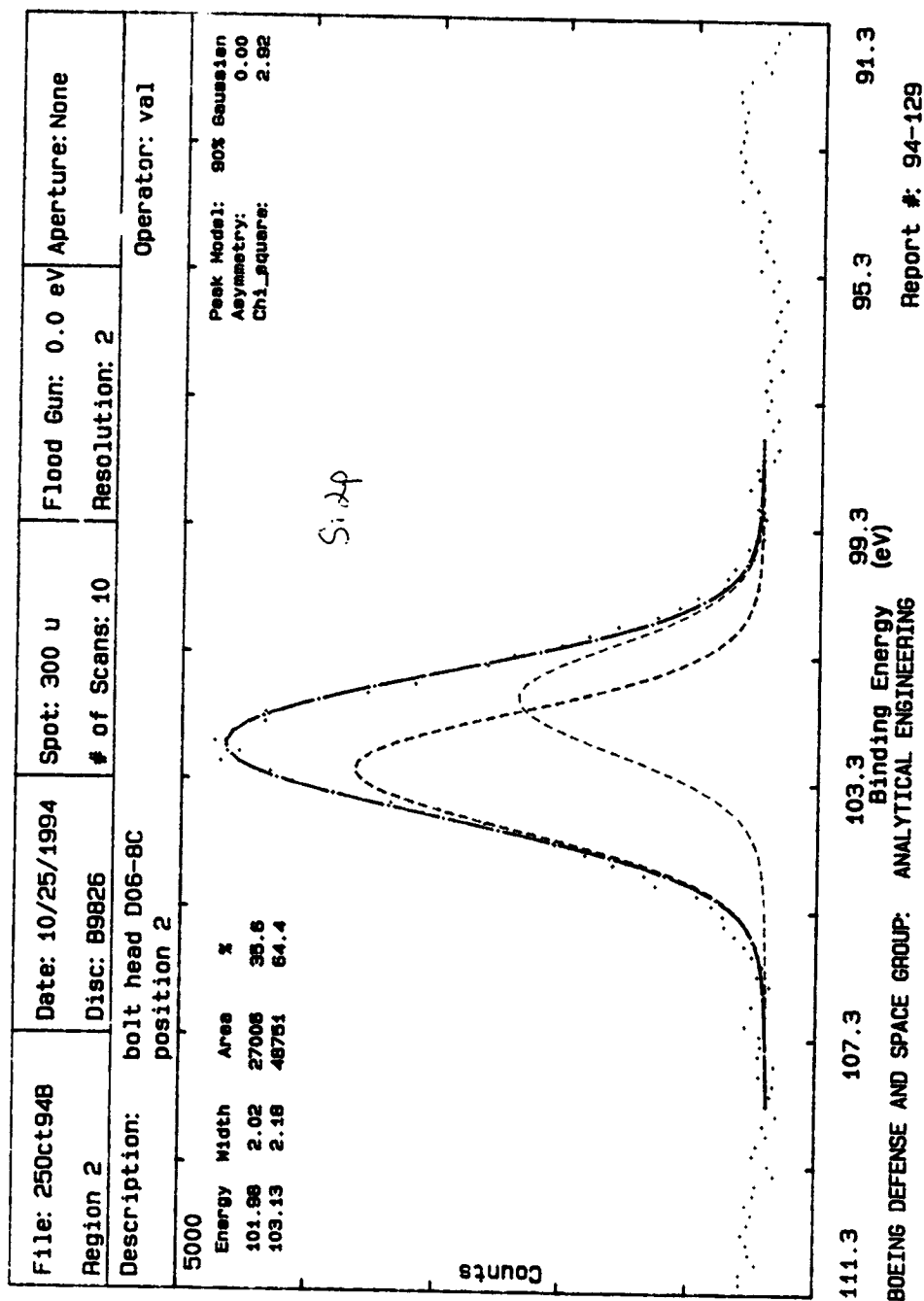


Figure G-45. Silicon 2p spectrum for bolt D6-8c, position 2.

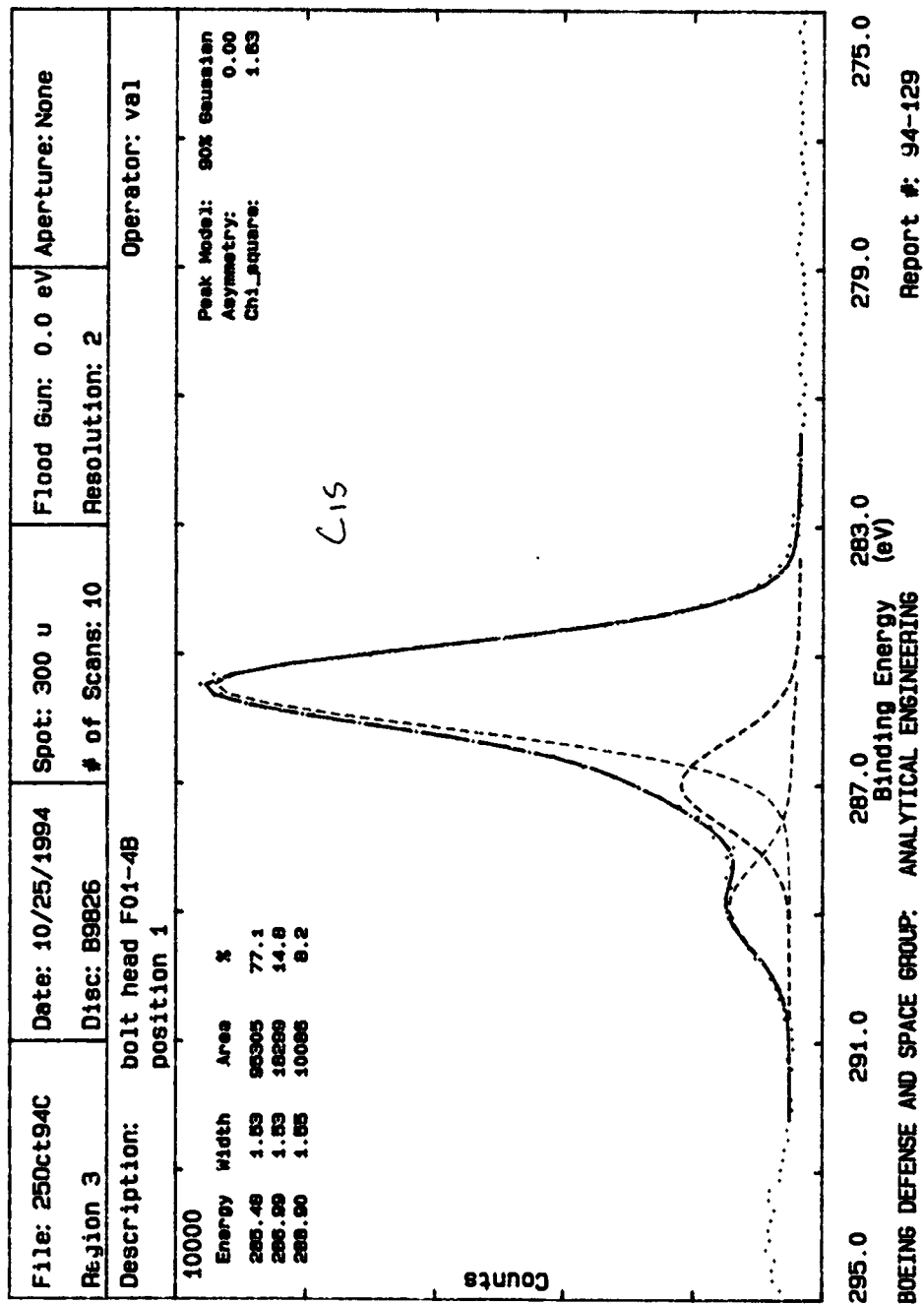


Figure G-46. Carbon 1s spectrum for bolt F1-4b, position 1.

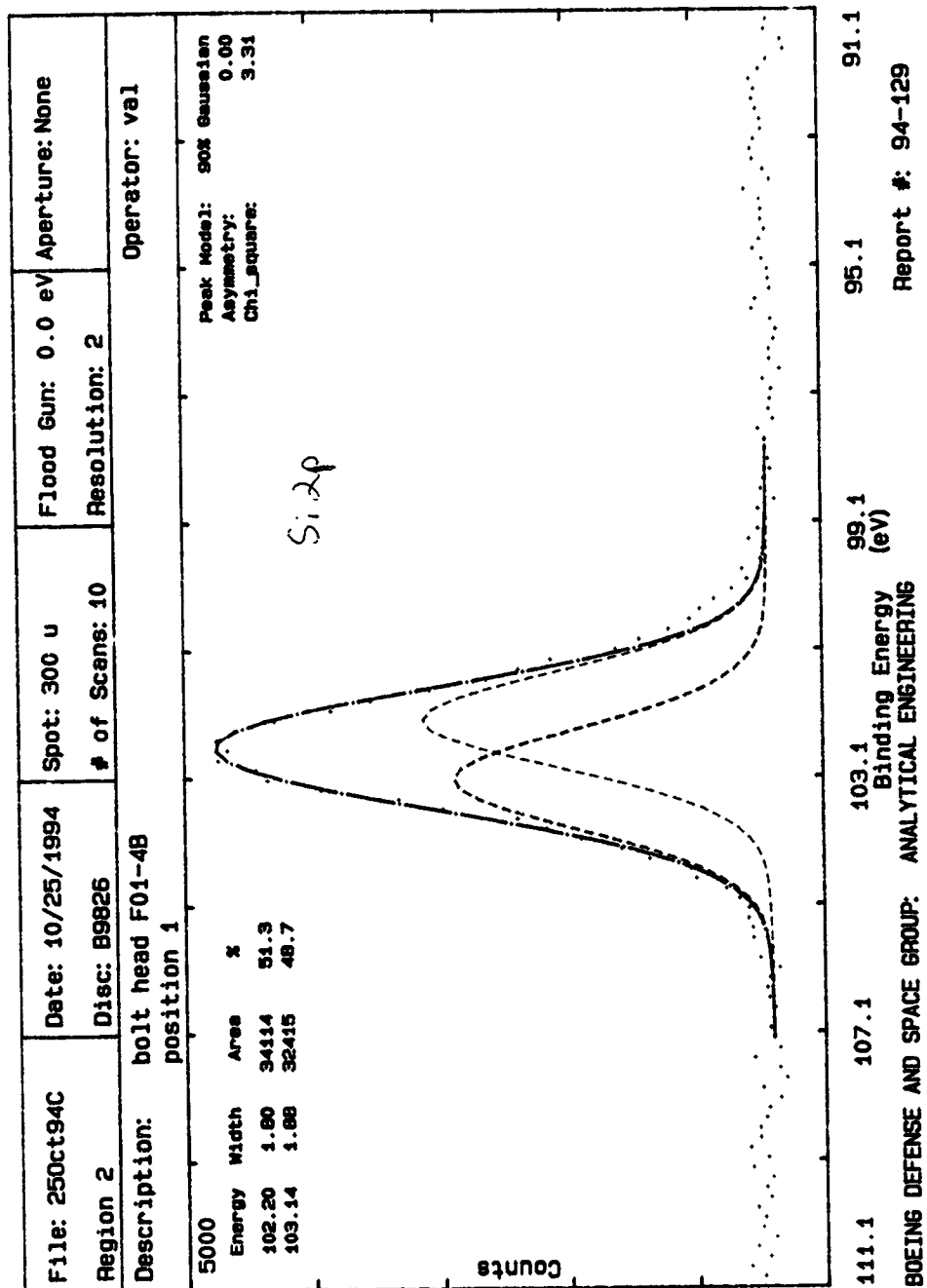


Figure G-47. Silicon 2p spectrum for bolt F1-4b, position 1.

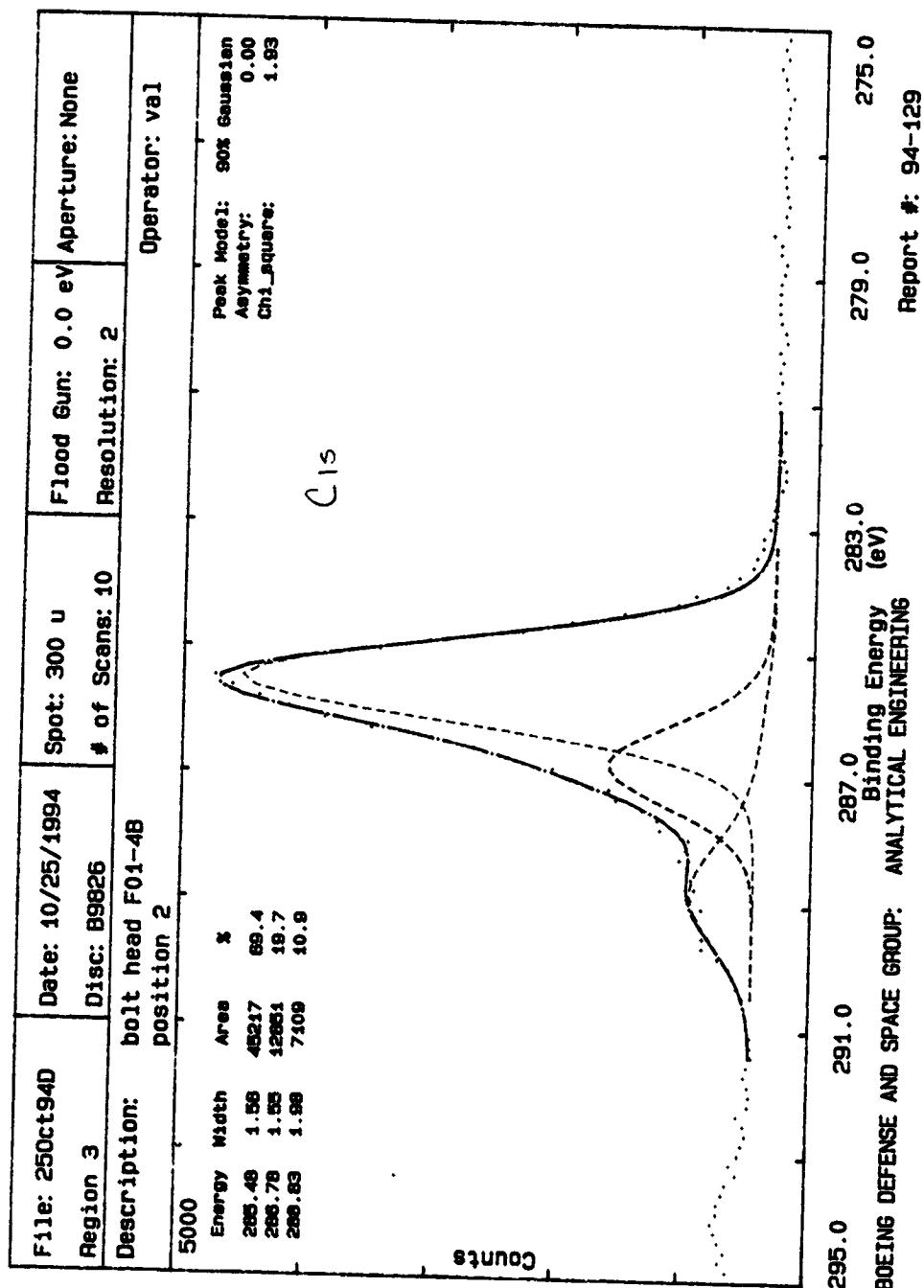
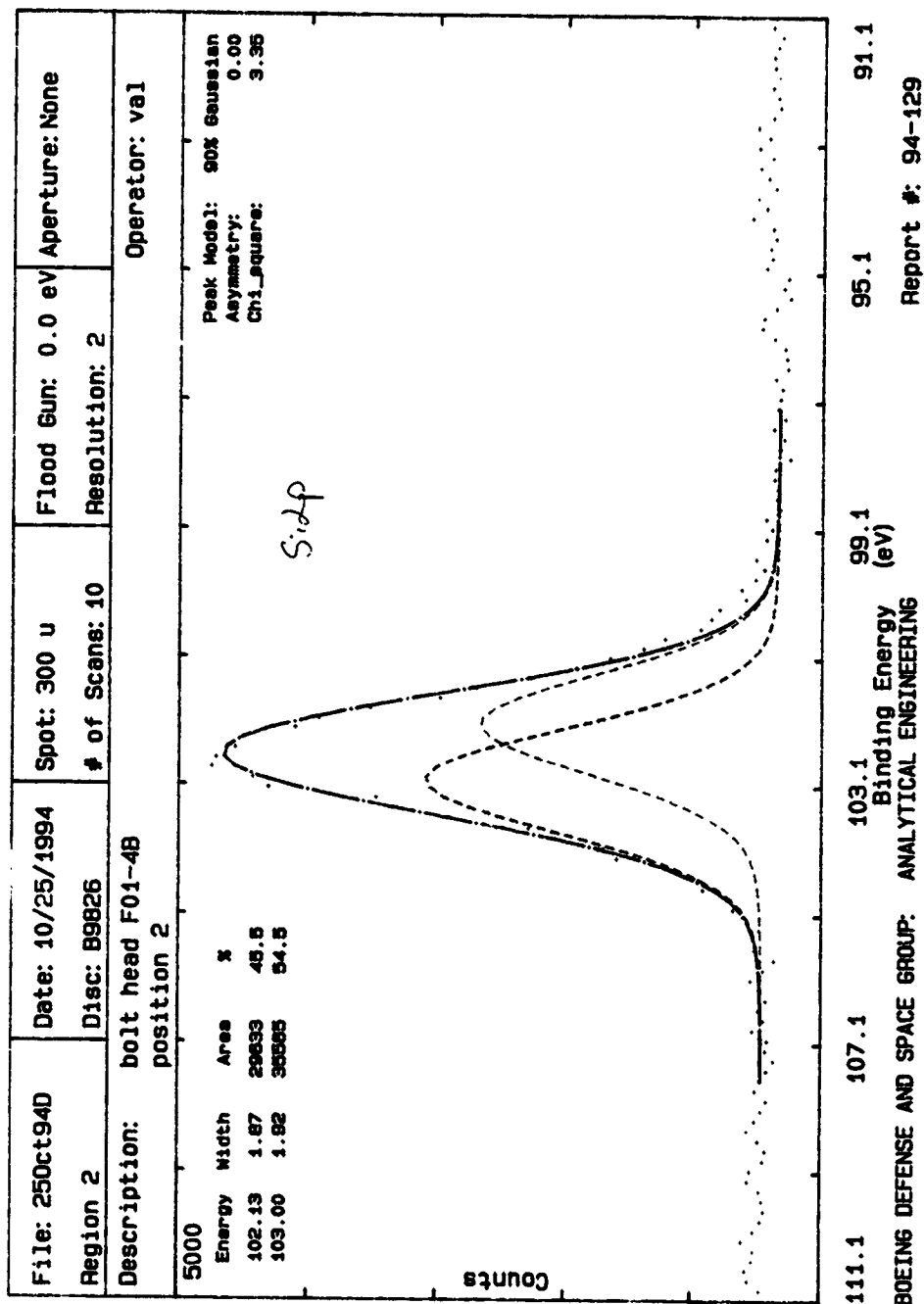


Figure G-48. Carbon 1s spectrum for bolt F1-4b, position 2.



Δbe = -0.9 eV

Figure G-49. Silicon 2p spectrum for bolt F1-4b, position 2.

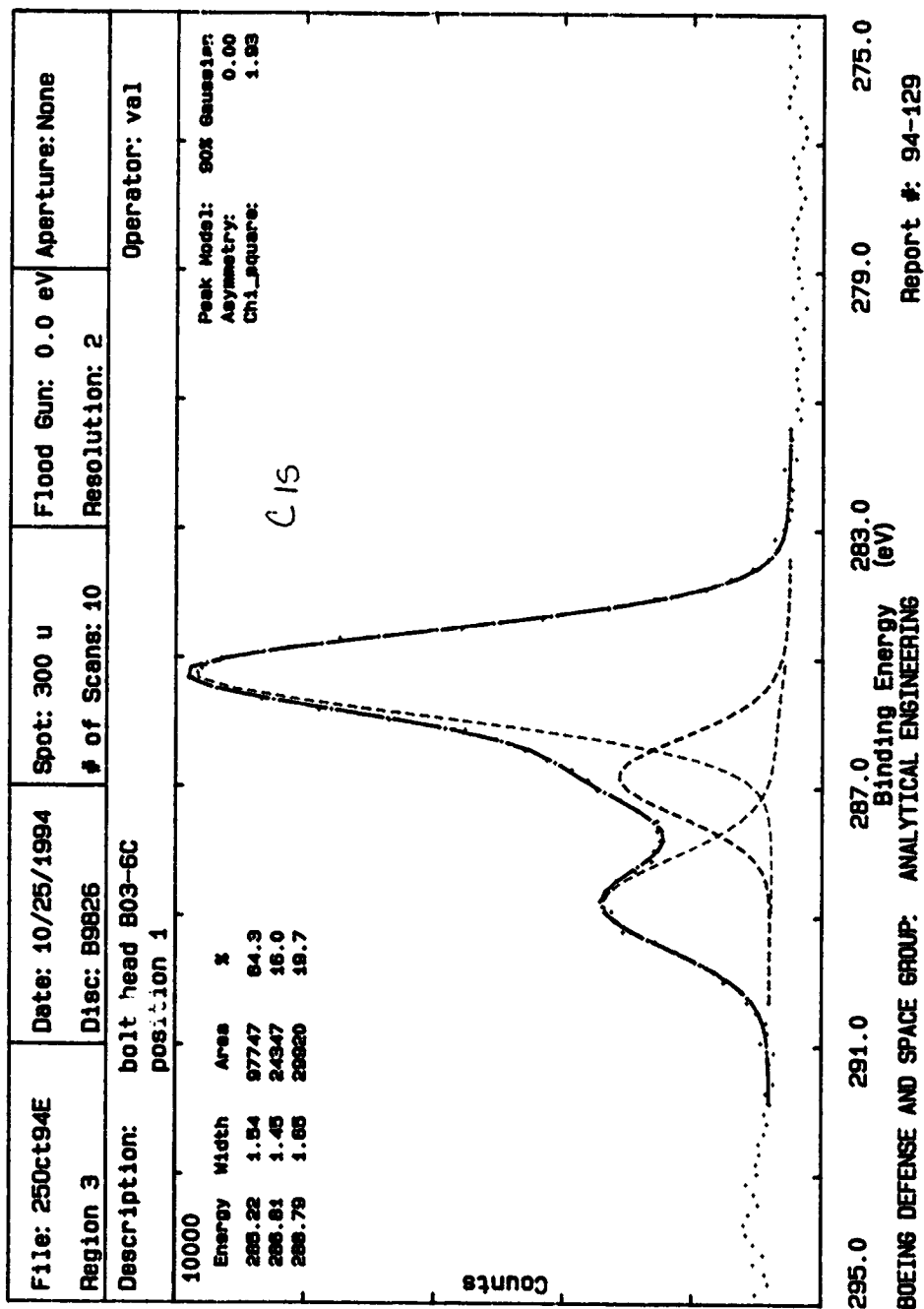
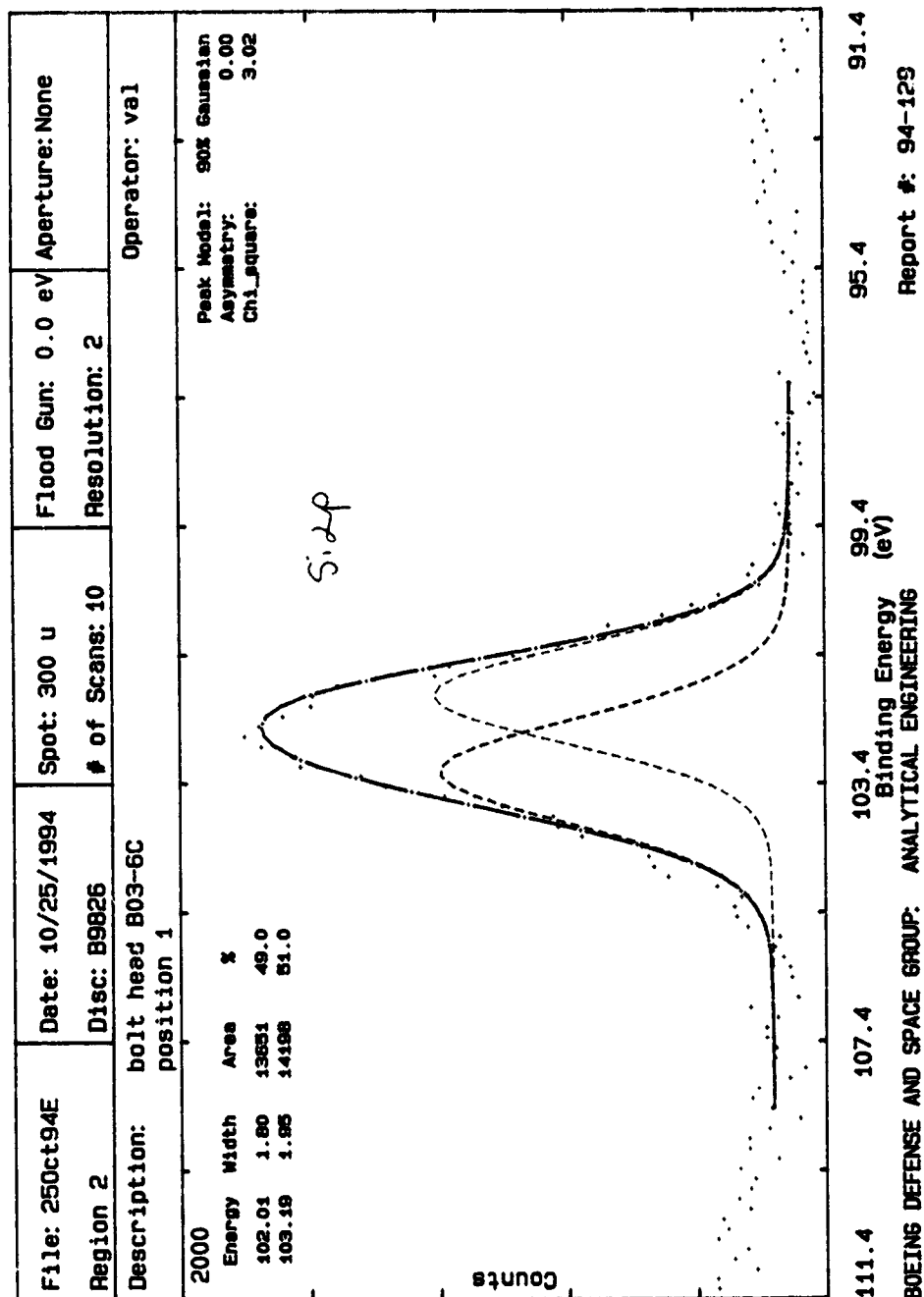


Figure G-50. Carbon 1s spectrum for bolt B3-6c, position 1.



102.01 = 0.6 eV

Figure G-51. Silicon 2p spectrum for bolt B3-6c, position 1.

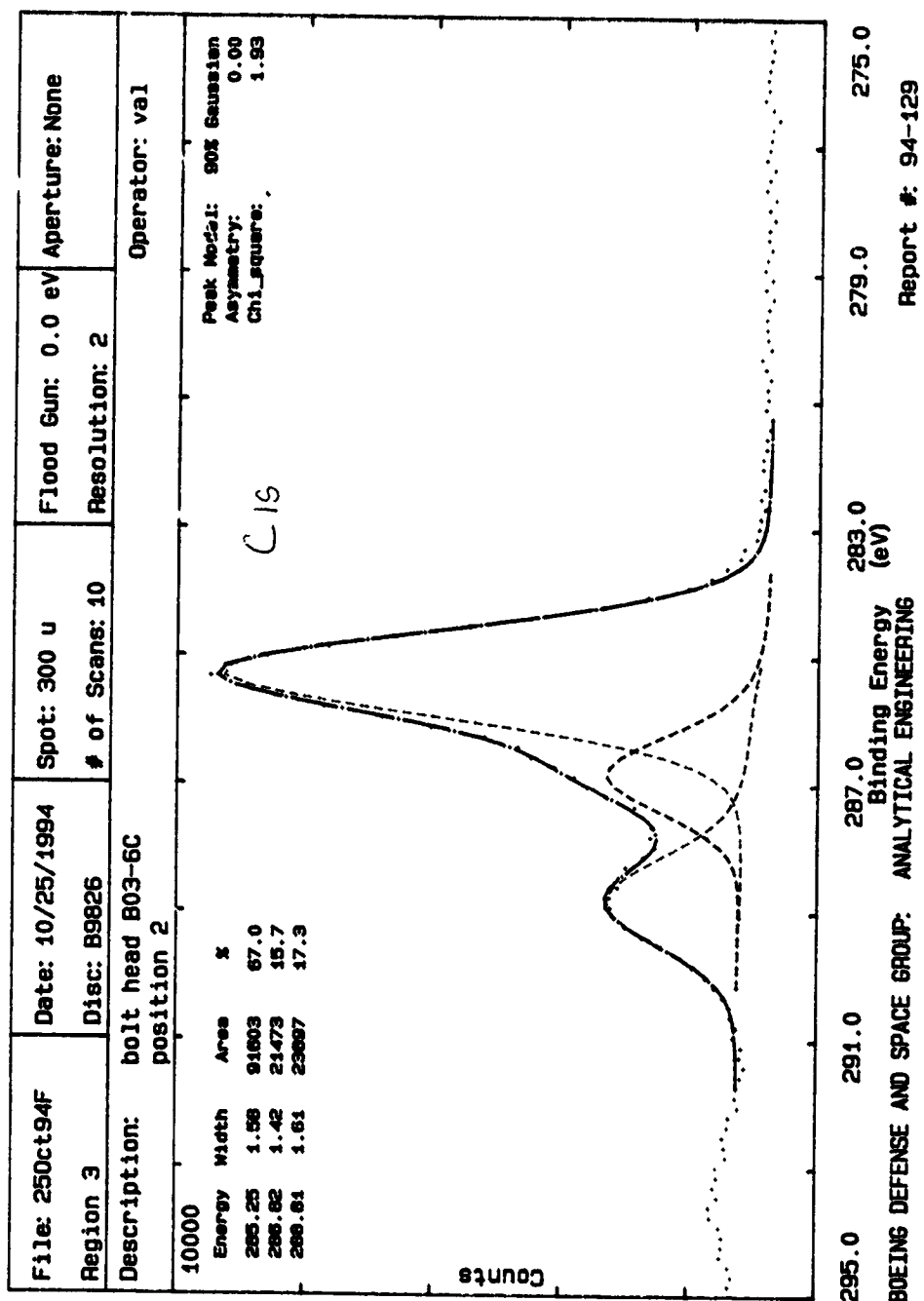


Figure G-52. Carbon 1s spectrum for bolt B3-6c, position 2.

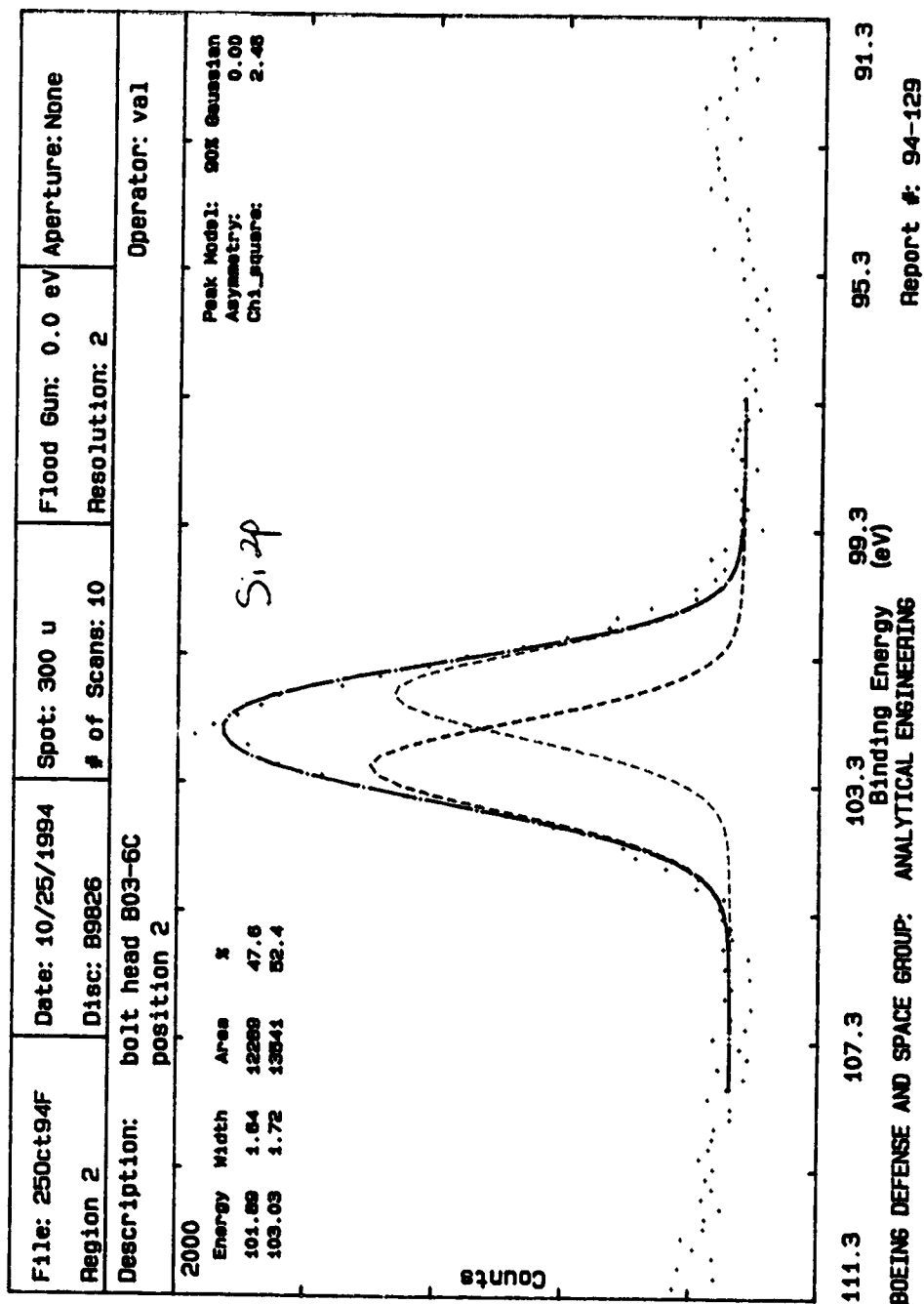


Figure G-53. Silicon 2p spectrum for bolt B3-6c, position 2.

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